DULUTH AIRPORT AUTHORITY

CONTRACT DOCUMENTS

Project No.3-27-0024-48-10
Contract No. SP 6901-164
RS&H No. 2131882.091

DULUTH INTERNATIONAL AIRPORT
NEW PASSENGER TERMINAL

VOLUME 3 OF 3

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REPLACEMENT PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

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NEW PASSENGER TERMINAL SECTION 15010 - BASIC MECHANICAL REQUIREMENTS
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PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.
2. Coordination drawings.
3. Record documents.
4. Maintenance manuals.
5. Codes, Permits and Inspections.
6. Separation of Work Between Trades.
7. Definitions and Interpretations.
8. Sustainable Building Submittal Requirements.
9. Utility Company Rebates
10. Operating Instructions
11. Guarantees and Certifications
12. Rough-In
13. Mechanical Installations
14. Cutting and Patching
15. Site Visitation Surveys and Measurements

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 15.

B. Division 15 Section "BASIC MECHANICAL MATERIALS AND METHODS," for materials and methods common to the remainder of Division 15.

C. This section is a part of each Division 15 Section.

1.3 APPLICABLE PUBLICATIONS: The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

A. Minnesota State Building code (MBC)

B. Air-Conditioning and Refrigeration Institute (ARI)

C. American National Standard Institute (ANSI)

D. Air Moving and Conditioning Association (AMCA)

E. American Society of Mechanical Engineers (ASME)

F. American Society for Testing and Materials (ASTM)

G. National Fire Protection Association (NFPA)

H. American Association of Balancing Contractors (AABC)

I. American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)

J. American Welding Society (AWS)

K. Cooling Tower Institute (CTI)

L. Environmental Protection Agency (EPA).

M. National Environmental Balancing Bureau (NEBB).

N. National Electrical Code (NEC)

O. Occupational Safety and Health Administration (OSHA).

P. Underwriters Laboratories (UL).

1.4 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and as specified in Division 1 Section "SUBMITTALS."

B. Prior to purchasing any equipment or materials, a list of their manufacturers shall be submitted for review.

C. Prior to assembling or installing the work, the following shall be submitted for review:

1. Scale drawings indicating insert and sleeve locations.

2. Scale drawings showing all piping and duct runs with sizes, elevations and appropriate indication of coordination with other trades. This submission to us shall consist of one sepia and 2 paper prints.

3. Catalog information, factory assembly drawings and field installation drawings as required for a complete explanation and description of all items of equipment.

4. Coordination drawings for access panel and door locations.

5. Shop drawings detailing fabrication and installation for supports for mechanical materials and equipment.

6. Mechanical Contractor shall submit complete MER sheet metal and piping shop drawings to the AC unit manufacturer prior to submission to the Engineer. The AC unit manufacturer shall approve the air performance and acoustical performance of the AC units in the location and with the ductwork and piping configuration and construction as indicated on the shop drawing. AC unit manufacturer shall indicate approval directly on the shop drawing.

7. Welder Certificates signed by Contractor certifying that welders comply with requirements specified under “Quality Assurance” in Section 15050.

D. Documents will not be accepted for review unless:

1. They include complete information pertaining to appurtenances and accessories.

2. They are submitted as a package where they pertain to related items.

3. They are properly marked with service or function, project name, where they consist of catalog sheets displaying other items which are not applicable.

4. They indicate the project name and address along with the Contractor's name, address and phone number.

5. They are properly marked with external connection identification as related to the project where they consist of standard factory assembly or field installation drawings.

E. Shop Drawing Review

1. The purpose of the review of shop drawings is to maintain integrity of the design. Unless the contractor clearly points out changes, substitutions, deletions or any other differences between the submission and the Contract Documents in writing on the Contractor's letterhead, approval by the Engineer or Architect does not constitute acceptance. It is not to be assumed that the engineer has read the text nor reviewed the technical data of a manufactured item and its components except where the Vendor has pointed out differences between his product and the specified model.

2. It is the responsibility of the contractor to confirm all dimensions, quantities, and the coordination of materials and products supplied by him with other trades. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

3. Substitutions of equipment, systems, materials, temperature controls must be coordinated by the Contractor with his own or other trades which may be involved with the item, such as, but not limited to, equipment substitutions which change electrical requirements, or hanging or support weights or dimensions.

4. Any extra changes or credits which may be generated by other trades due to substitutions will not be accepted unless the Contractor has an agreement in writing with the Owner.

5. Substitutions of equipment, systems, etc. requiring approval of local authorities must comply with such regulations and be filed at the expense of the Contractor (should filing be necessary). Substitutions are subject to approval or disapproval by the Engineer. The contractor in offering substitutions shall hold the Owner and Engineer harmless if the substituted item is an infringement of patent held by the specified item.

F. Explanation of Shop Drawing Stamp

1. Approval indicates that we have not found any reason why this item should not be acceptable within the intent of the documents.

2. As Noted indicates that we have found questionable components which if corrected or otherwise explained make the product acceptable.

3. Resubmit indicates that this item should be resubmitted for approval before further processing.

4. Not Accepted indicates that the item will not meet the intent of the Contract.

5. No shop drawing stamp or note shall constitute an order to fabricate or ship. Such notification can only be performed by the Project Manager for Construction, the Contractor scheduling his own work, or the Owner.

1.5 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 Section "PROJECT COORDINATION," to a scale of 1/4" = 1'-0" or larger; detailing major elements, equipment components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:

(a) Planned piping layout, including valve and specialty locations and valve stem movement.

(b) Planned duct system layout, including elbow radii and duct accessories.

(c) Clearances for installing and maintaining insulation.

(d) Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.

(e) Equipment connections and support details.

(f) Exterior wall and foundation penetrations.

(g) Fire-rated wall and floor penetrations.

(h) Sizes and location of required concrete pads and bases.

(i) Clearances as required by Electric Code.

2. Indicate piping loads and support points for all piping 3" and larger, racked piping, and submit to the Structural Engineer for review and approval. Indicate the elevation, location, support points, and loads imposed on the structure at support, anchor points, and size of all lines. Indicate all beam penetrations and slab penetrations sized and coordinated. Indicate all work routed underground or embedded in concrete by dimension to column and building lines.

3. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

4. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

5. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items.

B. HVAC TRADE COORDINATION DRAWINGS

1. This Trade shall prepare Coordination Drawings showing all of the HVAC work (equipment, piping,, ductwork, conduit, etc.) To be installed as part of the work of this section of the specifications. The Coordination Drawings shall be on reproducible transparencies at not less than 1/4" = 1'-0" scale.

2. Requirements for vibration isolation and seismic restraints shall be shown on the coordination drawings by each trade.

3. This Trade after showing all of the HVAC work shall forward the reproducible Coordination Drawings to the Plumbing Contractor.

4. The sequence of coordination drawings shall be HVAC-PLBG-FP-ELEC-GC.

5. The HVAC Contractor shall attend a series of meetings arranged by the General Contractor to resolve any real or apparent interferences or conflicts with the work of the other Contractors or with ceiling heights shown on the architectural drawings.

6. The HVAC Contractor shall then make adjustments to his work on the Coordination Drawings to resolve any real or apparent interferences or conflicts.

7. After any real or apparent interferences and conflicts have been incorporated into the Coordination Drawings, the HVAC Contractor shall “sign-off” the final Coordination Drawings.

8. The HVAC Subcontractor shall not install any of his work prior to “sign-off” of final Coordination Drawings. If HVAC work proceeds prior to sign-off of Coordination Drawings, any change to the HVAC work to correct the interferences and conflicts which result will be made by the HVAC Contractor at no additional cost to the project.

9. Coordination Drawings are for the HVAC Contractor’s and Owner’s use during construction and shall not be construed as replacing any shop, “as-built”, or Record Drawings required elsewhere in these Contract Documents.

10. Review of Coordination Drawings shall not relieve the HVAC Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirements of the Contract.

1.6 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, comply with the following.

1. A complete set of "as-built" or record drawings shall be made up and delivered to the Architect.

2. The drawings shall show:-

(a) Ductwork mains and branches, size and location, for both exterior and interior; locations of all dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.

(b) Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Refer to Division 15 Section "Mechanical Identification." Indicate horizontal locations of underground piping.

(c) Equipment locations (exposed and concealed), dimensioned from prominent building lines.

(d) Approved substitutions, Contract Modifications, and actual equipment and materials installed.

(e) All "main air" pneumatic control piping routing locations must be shown.

(f) Updating of all equipment schedule sheets.

B. This trade shall submit the "as-built" set for approval by the building department in a form acceptable to the department, when required by the jurisdiction.

C. The drawings shall be produced using AutoCad 2000 or later software. The design drawings will be made available on disks in AutoCad format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect and Engineer the drawing layers, colors, etc., of the CAD drawings. "As-built" information shall be submitted as follows:

1. CAD drawing files on disks in AutoCad 2000 format.

2. One (1) set of reproducible drawings.

3. Two (2) sets of blueprints.

D. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

E. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.

1.7 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions and lubrication charts and schedules.

5. List of spares: recommended for normal service requirements.

6. Parts list: identifying the various parts of the equipment for repair and replacement purposes.

7. Instruction books may be standard booklets but shall be clearly marked to indicate applicable equipment.

8. Wiring diagrams: generalized diagrams are not acceptable, submittal shall be specifically prepared for this project.

9. Automatic controls: diagrams and functional descriptions. (See control specification for additional requirements).

1.8 CODES, PERMITS AND INSPECTIONS

A. All work shall meet or exceed the latest requirements of all national, state, county, municipal and other authorities exercising jurisdiction over construction work at the project. These include, but are not limited to the following:

Minnesota State Building Code
NFPA National Fire Codes

B. All required permits and inspection certificates shall be obtained, paid for, and made available at the completion of the work.

C. Any portion of the work which is not subject to the approval of an authority having jurisdiction, shall be governed by the applicable sections of the overall National Fire Code, as published by the National Fire Protection Association.

D. Installation procedures, methods, and conditions shall comply with the latest requirements of The Federal Occupational Safety and Health Act (OSHA).

E. Prepare and submit to the building department a set of "as-built" record drawings for approval, in a form acceptable to the building department.

F. This Contractor shall prepare all plans, amendments and pay all filing fees that will be required for the fuel burning installation, including boiler plant, gas/oil fired chillers, chimney, oil piping, fuel oil tanks, gas piping, breeching, and any or all parts of the system under the jurisdiction of the controlling agencies.

G. This Contractor shall prepare all plans, amendments and pay all filing fees that will be required for the emergency generator installation, including oil piping, engine exhaust, fuel oil tanks, and any or all parts of the system under the jurisdiction of the controlling agencies.

H. This Contractor shall prepare all plans, amendments, and pay all filing fees that will be required for the electric generator and electric generator fuel oil tank installation.

I. This Contractor shall be responsible for the installation and filing until the installation has been approved by the authorities having such jurisdiction.

1.9 SEPARATION OF WORK BETWEEN TRADES

A. The specifications for the overall construction delineate various items of work under separate trade headings. The list below sets forth this delineation to the extent that

it affects the HVAC work.

B. In the absence of more detailed information, this list shall be taken as a specific instruction to the heating, ventilating and air conditioning trade to include the work assigned to it.

C. Indications that the heating, ventilating and air conditioning trade is to perform an item of work mean that it is to perform the work for its own accommodation only, except as specifically noted otherwise.

D. Oth = Other than electrical or mechanical

Plb = Plumbing

Htg = Heating, Ventilating & Air Conditioning

Elec = Electrical

f = Furnished

i = Installed

p = Provided (furnished and installed)

ITEM	OTH	PLB	HTG	ELEC	NOTES
Motors for mechanical equipment.			p		
Motors starters and control devices for mechanical equipment. Heating:			 p		 Specifications and drawings delineate exceptions.
Power wiring for mechanical equipment motors.				p	Specifications and drawings delineate exceptions.
Control wiring for motors. Heating:			 p		 Specifications and drawings delineate exceptions.
Wiring for automatic dampers. Heating:			 p		 Specifications and drawings delineate exceptions.
Temporary heat.	p				
Temporary water.	p				
Sealing of pressurized stairway, shafts and doors.	p				

ITEM	OTH	PLB	HTG	ELEC	NOTES
Undercutting of doors and door louvers.	p				Supplying location where required included in HVAC.
Temporary light & power.	p				
Hoisting			p		
Rigging			p		
Cutting, chasing & patching	p				Cost where due to late installation or improper coordination of work is the responsibility of the delinquent trade.
Framed slots and openings in walls decks and slabs.	p				Coordination drawings are required from HVAC trade.
Sleeves through non-membraned slabs, decks and walls.			p		
Drilling & cutting of all holes in steel decks and precast slabs required for sleeves & supports.			p		
Sleeves through membraned slabs, decks and walls.			p		
Waterproof sealing of sleeves through membraned slabs, decks and walls.			p		
Fireproof sealing of excess openings in slabs, decks & fire rated walls.			p		
Concrete encasement of underground runs			p		
Trenches in floor slabs	p				
Excavation and backfill inside buildings.	p				
Excavation and backfill outside buildings.	p				
Wells or openings in piping for pressure, temperature, flow, etc.			p		Wells and fittings furnished by Temperature Control subcontractor.
Keeping site and excavations free from surface water during construction.	p				To accommodate the overall project.

ITEM	OTH	PLB	HTG	ELEC	NOTES
Fastenings			p		
Supports			p		
Steam manholes	p				Furnishing of covers, associated frames and other hardware included in HVAC trade.
Base flashing to all roof penetrations	p				
Roof vent and pipe cap flashing.			p		
Roof vent and base flashing.	p				
Roof curb cap flashing.			p		
Roof curb base flashing	p				
Concrete foundations, pads & bases inside buildings.	p				Furnishing of anchors and vibration mounts included in the HVAC trade.
Concrete foundations, pads & bases outside buildings.	p				Furnishing of anchors and vibration mounts included in the HVAC trade providing the associated equipment.
Field touch-up painting of damaged shop coats.			p		
Rustproofing field cut and assembled iron supporting frames and racks.			p		
Finish painting of exposed work.	p				Insulation coatings are by HVAC trade.
Ornamental grills.	p				Duct connections included in HVAC trade.
Exterior wall louvers.	p				Duct connections & safing of all unused portions of louvers (2" thick insulated panel) is by HVAC Trade.
Finished wall and ceiling access doors, panels and supporting frames.	p				Supplying list locating all required access doors (none to be less than 16" x 16") included in HVAC.
Fire rated duct enclosures			p		
Thermal insulation for mechanical room ceilings.	p				

ITEM	OTH	PLB	HTG	ELEC	NOTES
Flue Vents			p		Coordinate with Plumbing Contractor.
Convector enclosures.	p		p		
Catwalks to mechanical equipment.	p				Supplying list of locations where required included in HVAC.
Ladders to mechanical equipment other than cooling towers					Supplying list of locations where required included in HVAC.
Ladders to cooling towers.			p		
Ladders to roof mounted AC units and equipment.			p		Coordinate with Architect and Structural Engineer.
Steel dunnage for roof mounted AC units and equipment other than cooling towers.			p		Coordinate with Architect and Structural Engineer.
Gas service piping to heating boiler equipment.		p			Final connections included in heating, ventilation and air conditioning.
Domestic make-up water piping for heating and air conditioning systems.		p			Final connections included in heating, ventilation and air conditioning.
Control valves for domestic hot water heaters.		f	i		
Walk-in refrigerator.	p				Line connections included in electric.
Laboratory and medical equipment.	p				line connections included in HVAC trade.
Rubbish removal			p		where one trade furnishes and another installs, the installing trade removes the shipping and packing materials which accumulate.
Special tools for equipment maintenance.			f		
Electric duct heaters (heaters installed in air ducts).			p		Line connections included in electric. Drawings delineate exceptions.
Electric heaters with integral fans (cabinet heaters, unit heaters and the like).			p		Line connections included in electric. Drawings delineate exceptions.

ITEM	OTH	PLB	HTG	ELEC	NOTES
Electric radiators (baseboard, sill line, and convector type heaters).				p	
Through wall sleeve type air conditioning and electric heating units.			p		
Electric heater cables for radiant space heating.				p	
Electric heater cables for snow melting.				p	
Electric heater cables for pipe tracing.				p	Line and control connections and control device mounting included in electric.
Masonry shafts, sheet rock shafts, tunnels, utilized for air ducts.	p				This trade to assure the air tightness of all joints, holes and other openings to make these air conveyors acceptable for their function.

E. The Heating, Ventilating and Air Conditioning Trade is required to supply all necessary supervision and coordination information to any other trades who are to supply work to accommodate the Heating, Ventilating and Air Conditioning installations.

F. Where the Heating, Ventilating and Air Conditioning trade is required to install items which it does not purchase, it shall include for such items:

1. The coordination of their delivery.

2. Their unloading from delivery trucks driven in to any designated point on the property line at grade level.

3. Their safe handling and field storage up to the time of permanent placement in the project.

4. The correction of any damage, defacement or corrosion to which they may have been subjected.

5. Their field assembly and internal connection as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage supporting members and fastenings necessary to adapt them to architectural and structural conditions.

7. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

G. Items which are to be installed but not purchased as part of the work of the Heating, Ventilating and Air Conditioning trade shall be carefully examined by this trade upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of work of the Heating, Ventilating and Air Conditioning trade will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The work of the Heating, Ventilating and Air Conditioning trade shall include all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.10 DEFINITIONS AND INTERPRETATIONS

A. Specific items of terminology, as used herein or on drawings, shall have the following meanings.

1. "Piping"----------Pipe, fittings, flanges, valves, controls, hangers, traps, drains, insulation, vents, and items customarily required in connection with the transfer of fluids.

2. "Concealed"----------Embedded in masonry or other construction, installed behind wall furring, within double partitions or hung ceilings, in crawl spaces, in shafts.

3. "Exposed"----------Not concealed.

4. "By Other Trades" or "Others" or "Oth"-------By persons or parties responsible for work at the project other than the party or parties who have been duly awarded the contract for the work of this Trade. In the event that this document is used to acquire work as part of a general construction contract the words "by other trades" shall mean by persons or parties who are not anticipated to be the sub-contractor for this trade working together with the general contractor. In this context the words "by other trades" shall <u>not</u> be interpreted to mean not included in the overall contract.

5. Where reference is made to N.E.M.A. Standards, it shall be understood that this reference is to the "Approved Standards", published by the National Electrical Manufacturers Association, Main Office - 155 East 44th Street, New York, New York 10017.

6. Where reference is made to "A.N.S.I. Standards", it shall be understood that this reference is to the standards published by the American National Standards Institute Incorporated.

1.11 INTERPRETATION OF THE DRAWINGS AND SPECIFICATIONS:

A. As used in the drawings and specifications, certain non technical words shall be understood to have specific meanings as follows:

1. "Furnish"----------Purchase and deliver to the project site complete with every necessary appurtenance and support.

2. "Install"----------Unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project.

3. "Provide"----------"Furnish" and "Install".

B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

C. It shall be understood that the specifications and drawings are complementary and are to be taken together for a complete interpretation of the work. Where there are conflicts between the drawings and specifications or within the specifications or drawings themselves, the items of higher standard shall govern.

D. No exclusions from, or limitations, in the language used in the drawings or specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are to be omitted.

E. The drawings of necessity utilize symbols and schematic diagrams to indicate various items of work. Neither of these have any dimensional significance nor do they delineate every item required for the intended installations The work shall be installed, in accordance with the diagrammatic intent expressed on the electrical and mechanical drawings, and in conformity with the dimensions indicated on final architectural and structural working drawings and on equipment shop drawings.

F. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded.

G. Certain details appear on the drawings which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the indicated work.

H. Information as to the general construction shall be derived from structural and architectural drawings and specifications only.

I. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

J. In the event that extra work is authorized, and performed by this trade, work shown on drawings depicting such work, and/or described by Bulletin is subject to the base building specifications in all respects.

1.12 CONTRACTOR'S RESPONSIBILITY REGARDING UTILITY COMPANY REBATE PROGRAMS

A. <u>This Contractor shall as part of his quotation for Base Bid work, include work in connection with Utility Company rebate programs as follows:</u>

1. For equipment which qualify for rebates from the Utility and which have been included in the Base Bid work as part of these specifications and/or the associated contract drawings, assist in the preparation of all applications, work sheets, and other documentation required by the Utility in order to insure their eligibility for rebate. In order to avoid possible loss of rebates,

obtain written confirmation of eligibility from the Utility Company before placing orders for any such equipment. Schedule the filing of the documentation, the ordering of the equipment, and the installation of the equipment so as to guarantee compliance with all of Utility Company requirements. Notify the Architect in writing if these requirements will delay the building construction schedule.

1.13 SUSTAINABLE (LEED AND STATE OF MINNESOTA)

A. LEED Building Submittal Requirements

1. Contractor's Responsibility Regarding Rebate Programs, Tax Credits and Green Building Certifications

(a) This section applies to all projects in regard to available rebate programs but only requires adherence to the special programs listed when such programs are specifically called out to be part of the project. This Contractor shall as part of his quotation for Base Bid work, include work in connection with Utility Company, Local, State, and Federal rebate programs as follows:

(1) For equipment which qualify for rebates and which have been included in the Base Bid work as part of these specifications and/or the associated contract drawings, assist in the preparation of all applications, work sheets, and other documentation required in order to insure their eligibility for rebate. In order to avoid possible loss of rebates, obtain written confirmation of eligibility from the agency offering the rebate and/or CM before placing orders for any such equipment. Schedule the filing of the documentation, the ordering of the equipment, and the installation of the equipment so as to guarantee compliance with all requirements. Notify the Architect in writing if these requirements will delay the building construction schedule.

(2) Contractor shall provide Owner assistance to meet the requirements of, the State of Minnesota Sustainable Buildign Guidelines (MSBG) and , the United States Green Building Council (USGBC) LEED™ New Construction Certification Program, Building Tax Credit (MSBG). This project must be in full compliance with the requirements of these programs. The Contractor is responsible to provide all information that is needed for the satisfactory demonstration of compliance as mandated in these guidelines. Compliance is required with all but not limited to the following:

(i) BUDGETING / COSTING

Contractor shall provide cost data from vendors and for their own work for all Energy Efficiency Measures (EEMs). Where guidelines provide alternative approaches to requirements such as the MSBG, the Contractor shall perform cost comparisons to assist the Owner and the design team in selecting the best option. Where guidelines require reporting of incremental cost differences between equipment and systems such as with the MSBG, the Contractor shall perform cost comparisons to assist the Owner in developing the required reports.

(ii) COMPLIANCE WITH REQUIRED PLANS FOR FIELD OPERATIONS

Contractor is responsible for compliance with all plans developed specifically for these programs as follows:

1) Erosion and Sedimentation Plan - This plan includes a description of all temporary and permanent erosion control and stormwater control measures implemented on the project site and the type and frequency of maintenance activities required for the chosen erosion control methods. Compliance shall be monitored by a CM staff member regularly assigned to this task. A book including photographs of the site taken on a regular basis, forms for notification of non-compliance with the plan, and forms for noting the correction of non-compliant situations shall be maintained at the field office.

2) IAQ (Interior Air Quality) Plan compliant with MSBG and LEED. The plan should include specific actions and protective measure proposed for this particular site including descriptive narratives, detailed sketches, construction and pre-occupancy building flush, and Mold Mitigation program relative to the following requirements:

a) Electrical Protection

All electrical equipment must be protected from collecting not only dust but also, moisture and odors (which can "stick" to porous materials in the system and later be re-released). Bus duct and conduit are to be delivered to the site with ends covered. During construction and for all work in place, all open ends shall be covered.

b) Source Control

Contractors shall use products with low VOCs (Volatile Organic Compounds) and must use low sulfur fuels. This section also mandates field operating practices to reduce air borne contaminants and emissions.

c) Pathway Interruption

Pathway Interruption measures are required where areas are potentially subject to contamination from construction activities. Contractors as examples may be required to erect barriers to contain dust or relocate staging areas from air pathways or provide temporary sealing of intakes to avoid contamination.

d) Housekeeping

Specific actions shall be employed by all Contractors in regard to controlling contaminates at the work site.

e) Scheduling

Contractors must maintain schedules to ensure construction activity and building occupancy do not overlap in time. This also calls for a flush-out of areas to be occupied for two weeks with 100% outside air to remove any residual dust or odors from the space. Subcontaractors shall provide all standby labor required for this operation including a change of filters immediately after.

f) Sequence of Finish Installation

Finishes shall be sequenced to avoid porous materials absorbing emissions from wet-applied finishes. Contractors shall include appropriate allowances for drying or curing times of wet-applied finishes before installation of porous finishes and materials, based on technical specifications provided by the manufacturers.

g) Material Protection

Materials directly exposed to moisture through precipitation, plumbing leaks or condensation from HVAC equipment are susceptible to microbial contamination. The contractor shall take precautions necessary to protect materials installed or stored on-site from moisture damage and develop a Mold Mitigation program.

The project's designated Construction IAQ Manager is responsible for implementation and enforcement of the Construction IAQ Management requirements and has the authority to implement stop work orders or termination of services for non-conformance with the requirements herein.

3) Construction Waste Management Plan - The rubbish removal plan shall provide for the handling and sorting of construction waste. Compliance with the plan is required by all Contractors

4) Pest Control Management Plan - In compliance with MSBG Guidelines this plan calls for the use of non-toxic pesticides and the use of boric acid for insect control. Compliance with the plan is required by all Contractors.

(iii) Minnesota Sustainable Building Guideline (MSBG) Submittal Requirements:

The Contractor and their sub-contractors shall submit the “MSBG” certification items listed herein. “MSBG” submittals shall include the following:

1) All completed “MSBG” Materials Certification Forms. Information to be supplied for this form shall include:

   a) Cost breakdowns for the adhesives and sealants included in the Contractor or sub-contractor's work and listed under the “MSBG” PERFORMANCE CRITERIA in Section 16050 - Basic Electrical Materials & Methods. Cost breakdowns shall include total cost plus separate labor, equipment, and itemized material costs.

   b) The VOC content of all adhesives, sealants, paints, and coatings applied on site as part of this work.

2) Product cut sheets for materials that meet the “MSBG” CERTIFICATION FORM. Cut sheets shall be submitted with the Contractor or sub-contractor's stamp, as confirmation that the submitted products are the products installed in the Project.

3) Material Safety Data Sheets (MSDS), for applicable products. Applicable products include, but are not limited to adhesives, sealants, carpets, paints and coatings. Material Safety Data Sheets shall indicate the Volatile Organic Compound (VOC) limits of products submitted (If an MSDS does not include a product's VOC limits, then product data sheets, manufacturer literature, or a letter of certification from the manufacturer can be submitted in addition to the MSDS to indicate the VOC limits).

4) Published product literature or letters of certification (on the manufacturer's letterhead) indicating the mercury content of each fluorescent lamp type installed.

5) The “MSBG” submittal information shall be assembled into one (1) package per Section or trade, and sent to the Consultant of review. Incomplete or inaccurate “MSBG” submittals may be used as the basis for rejecting the submitted products or assemblies.

(iv) Commissioning

Commissioning and training requirements shall be in accordance with the Commissioning specification section.

General Description of Roles:

A/E: Write requirements for start-up and pre-functional tests, perform construction observation, approve O&M manuals, respond to RFIs, clarify design intent and assist in resolving problems.

CA: Provide document reviews, coordinate the Cx process, write procedures and Commissioning Plan, oversee and compile documentation of pre-functional check lists, write functional performance tests for the commissioning plan, witness, in part, pre-functional tests, witness functional tests, comply results of Commissioning and training.

Mfr.: The equipment manufacturers and vendors provide documentation to facilitate the commissioning work, perform contracted startup, and participate in the proper operation of their equipment during functional and system testing, and training.
Subs: Assists in the preparation of all testing procedures, demonstrate proper system performance and provides all labor and testing apparatus required for start-up, functional and system testing, commissioning and training.

CM: Facilitates the Cx process ensures that Subs perform their responsibilities and integrates Cx into the construction process and schedule.

(v) Required Plans and Records for Sustainable/ Renewable Materials:

Submittals are to be reviewed by the Green and Sustainability Consultant to assure they include the required information for adherence to all programs. Subcontracts shall provide all data required to assure compliance.

(vi) Purchasing/Contracting/Record Keeping:

All Contractors, Material suppliers, and Vendors shall include the cost of supplying specified materials (mostly low VOC sealants, coatings, paints, carpet, insulation, etc.), specified by AA, in compliance with MSBG and LEED Guidelines. All Contractors shall include the cost of performing the installation of materials in accordance with details specified by AA, in compliance with LEED and BPCA, Guidelines.

2. Delivery, Storage, and Handling

(a) Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

(b) Unit shall be stored and handled in accordance with manufacturer's instructions.

(c) Unit shall be shipped with all listed items and control wiring factory installed unless noted on the submittals and approved prior to shipment.

(d) Unit shall be shipped complete as specified. Parts for field installation shall not be shipped and stored on site without prior approval.

(e) Rigging: Units shall be fully assembled. Units requiring disassembly for rigging shall be factory assembled and tested. Disassembly, reassembly and testing shall be supervised by the manufacturer's representative.

(f) Unit shall be shipped with firmly attached labels that indicate name of manufacturer, model number, serial number, and plan tagging.

(g) The Vendor shall shrink-wrap all electronic equipment and spare parts prior to shipping. Spare parts are to be delivered at time of owner acceptance.

3. Preconstruction Conference Prior to Start of Work

(a) Prior to commencing any Work, the CM, together with designated major Contractors, shall confer with the Architect and Engineer concerning the Work under the Construction Contract.

(b) The pre-construction conference will be conducted under the leadership of the CM and will occur soon after the CM notifies the Subcontractors of contract award. The pre-construction conference will focus on items such as the expedited submittal review procedure, interface and coordination between Contractor work scope, the CM's project site rules and requirements, temporary utility requirements, CM's construction schedule, etc.

B. Shop Drawing Review

1. The purpose of the review of shop drawings is to maintain integrity of the design. Unless the contractor clearly points out changes, substitutions, deletions or any other differences between the submission and the Contract Documents in writing on the Contractor's letterhead, review by the Engineer or Architect does not constitute acceptance. It is not to be assumed that the engineer has read the text nor reviewed the technical data of a manufactured item and its components including where the Vendor has pointed out differences between his product and the specified model.

2. It is the responsibility of the contractor to confirm all dimensions, quantities, and the coordination of materials and products supplied by him with other trades. Review of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

3. Substitutions of equipment, systems, materials, temperature controls must be coordinated by the Contractor with his own or other trades which may be involved with the item, such as, but not limited to, equipment substitutions which change electrical requirements, or hanging or support weights or dimensions.

4. Any extra changes or credits which may be generated by other trades due to substitutions will not be accepted unless the Contractor has an agreement in writing with the Owner.

5. Proposed substitutions shall be in accordance with the requirements of the section governing substitutions. Substitutions of equipment, systems, etc. requiring approval of local authorities must comply with such regulations and be filed at the expense of the Contractor (should filing be necessary). Substitutions are subject to approval or disapproval by the Engineer. The contractor in offering substitutions shall hold the Owner and Engineer harmless if the substituted item is an infringement of patent held by the specified item.

C. Explanation of Shop Drawing Stamp

1. Reviewed - No Exception Taken: indicates that we have not found any reason why this item should not be acceptable within the intent of the contract documents.

2. Exception Taken As Noted: indicates that we have found questionable components which if corrected or otherwise explained make the product acceptable.

3. Revised and Resubmit: indicates that this item should be resubmitted for review before further processing.

4. Resubmit Specified Item: indicates that the item will not meet the intent of the Contract.

5. Incomplete - Resubmit: Indicates that the submission is not complete and ready for review by the Architect or Engineer.

6. No shop drawing stamp or note shall constitute an order to fabricate or ship. Such notification can only be performed by the Project Manager for Construction, the Contractor scheduling his own work, or the Owner.

7. The Contractor is responsible for having "Reviewed" copies of shop drawings bearing the Reviewed - No Exception Taken stamp of the Architect/Engineer or Owner's Consultant are kept on the job site and work is implemented in the field in accordance with these documents.

8. Where information from one Contractor is required by another contractor, it is the responsibility of the contractors to exchange information and coordinate their work.

1.14 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 OPERATING INSTRUCTIONS

A. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

3.2 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from leaks or defects. Any defective materials or workmanship as well as damage to the work of all trades resulting from same shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use. For example, in the case of refrigeration systems, it means that the plant has a cooling load. Similarly, for all other systems.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Non-durable replaceable items such as air filter media do not require replacement after the date of acceptance. If received in writing, requests to have earlier acceptance dates established for these items will be honored.

E. Certification shall be submitted attesting to the fact that specified performance

criteria are met by all items of heating and air conditioning equipment.

3.3 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.4 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate mechanical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.

8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

11. Install access panel or doors for maintenance or inspection where units are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "ACCESS DOORS" and Division 15 Section "BASIC MECHANICAL MATERIALS AND METHODS."

12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

3.5 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section "CUTTING AND PATCHING." In addition to the requirements specified in Division 1, the following requirements apply:

1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:

1. Uncover Work to provide for installation of ill-timed Work.

2. Remove and replace defective Work.

3. Remove and replace Work not conforming to requirements of the Contract Documents.

4. Remove samples of installed Work as specified for testing.

5. Install equipment and materials in existing structures.

6. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.

C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, heating units, plumbing fixtures and trim, and other mechanical items made obsolete by the new Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

1. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

(a) Refer to Division 1 Section "DEFINITIONS AND STANDARDS" for definition of "experienced Installer."

2. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.

(a) Refer to Division 1 Section "DEFINITIONS AND STANDARDS" for definition of "experienced Installer."

3.6 SITE VISITATION SURVEYS AND MEASUREMENTS

A. Before submitting bid, visit the project site to satisfy yourself that all equipment shown or specified in the project contract documents can be installed generally as shown. Advise Owner prior to bid date, of any space or other installation problems.

B. Before submitting bid, become thoroughly familiar with all conditions under which work will be installed, as you will be held responsible for any assumptions, any omissions or errors made as a result of failure to become familiar with the site and Contract Documents.

C. Investigate each space through which equipment must be moved. Where necessary, equipment shall be shipped from manufacturer in sections of size suitable for moving through restrictive spaces available. Ascertain from building Owner at what time of day equipment may be moved through certain restrictive areas.

D. Install work so as to be readily accessible for operation, maintenance and repair. Minor deviations from drawings may be made to accomplish this, but changes which involve extra cost shall not be made without approval.

E. Removal and relocation of certain existing work will be necessary for the performance of the general work. All existing conditions cannot be completely detailed on the drawings. The Contractor shall survey the site and include all required changes in making up their bid proposal.

F. Submission of a bid shall be construed as evidence, that a careful examination of the portions of the existing building, equipment, etc., which affect this work and the access to such spaces has been made and that the Contractor is familiar with existing conditions and difficulties that will affect the execution of the work. Claims will not be allowed for labor, equipment or materials required because of difficulties encountered, which could have been foreseen during such an examination.

END OF SECTION 15010

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15050 - BASIC MECHANICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following basic mechanical materials and methods to complement other Division 15 Sections.

1. Piping materials and installation instructions common to most piping systems.

2. Fire and smoke Detection

3. Sequencing and scheduling

4. Access Doors in Finished construction.

5. Dielectric Fittings.

6. Pipe and Pipe Fittings.

7. Joining Materials

8. Piping Specialties

9. Labeling and identifying mechanical systems and equipment is specified in Division 15000.

10. Grout for equipment installations.

11. Drive Guards

12. Electrical Motors, Motor Controls and Wiring

13. Firestopping

14. Tools and lubricants

15. Dampers - General

16. Damper Terminal Strips

17. Automatic Control Valves - General

18. Piping Systems - Common Requirements.

19. Pressure Testing - All Piping Systems.

20. Equipment Installation - Common Requirements.

21. Labeling and Identifying

22. Painting and finishing.

23. Pans and Drains over Electrical Equipment.

24. Concrete Bases

25. Erection of Metal Supports and Anchorage

26. Welding procedure.

27. Excavation and backfill.

B. Pipe and pipe fitting materials are specified in piping system Sections.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and the Supplementary Conditions and Division 1 Specification Sections, apply to this and other sections of Division 15.

B. Excavation and backfill: Section 02200, EARTHWORK.

C. Section 03300, CAST-IN PLACE CONCRETE.

D. Section 05311, STEEL ROOF DECK.

E. Section 05321, STEEL FLOOR DECK.

F. Section 05500, METAL FABRICATIONS.

G. Section 07250, FIRESTOPPING.

H. Flashing wall and roof penetrations: Section 07600, FLASHING AND SHEET METAL.

I. Section 07920, SEALANTS AND CAULKING.

J. Section 09900, PAINTING.

K. Division 15, MECHANICAL

L. Division 16, ELECTRICAL

M. Other Sections where applicable.

1.3 QUALITY ASSURANCE

A. Qualify welding processes and operators for structural steel according to AWS D1.1 "Structural Welding Code--Steel."

B. Qualify welding processes and operators for piping according to ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications."

1. Comply with provisions of ASME B31 Series "Code for Pressure Piping."

2. Certify that each welder has passed AWS qualification tests for the welding processes involved and that certification is current.

C. Products Criteria:

1. All equipment furnished as part of the work shall comply with the latest editions of all applicable state and municipal "energy codes." Provide certification from the equipment suppliers for all energy-consuming equipment that the equipment fully complies with these codes. Equipment submissions will not be accepted for review unless accompanied by such certification in writing.

2. All equipment and materials shall be new and without blemish or defect.

3. New equipment and materials shall be Underwriters Laboratories, Inc. (U.L.) labeled and/or listed where specifically called for, or where normally subject to such U.L. labeling and/or listing services.

4. All equipment and materials shall be free of asbestos.

5. Electrical equipment and materials shall be products which will meet with the acceptance of the agency inspecting the electrical work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be examined, tested and certified.. Where no specific indication as to the type or quality of materials or equipment is indicated, a first class standard article shall be furnished.

6. It is the intent of these specifications that wherever a specific manufacturer of a product is specified or scheduled, and the specifications include other approved manufacturers or the terms "other approved" or "or approved equal" or "equal" are used, the submitted item must conform in all respects to the specified item. Consideration will not be given to claims that the submitted item meets the performance requirements with lesser construction (such as lesser heat exchange surface, smaller motor HP, etc.). Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance. In many cases equipment is oversized to allow for pick-up loads which cannot be delineated under the minimum performance.

7. All equipment of one type (such as fans, pumps, coils, etc.), shall be the products of one Manufacturer.

8. Substituted equipment or optional equipment where permitted and approved, must conform to space requirements. Any substituted equipment that cannot meet space requirements, whether approved or not, shall be replaced at the Contractor's expense. Any modifications of related systems as a result of substitutions shall be made at the Contractor's expense.

9. Note that the approval of shop drawings, or other information submitted in accordance with the requirements hereinbefore specified, does not assure that the Engineer, Architect, or any other Owner's Representative, attests to the dimensional accuracy or dimensional suitability of the material or equipment involved or the ability of the material or equipment involved or the mechanical performance of equipment. Approval of Shop Drawings does not invalidate the plans and specifications if in conflict, unless a letter requesting such change is submitted and approved on the Engineer's letterhead.

10. Substitutions of Mechanical Equipment for that shown on the schedules or designated by model number in the specifications will not be considered if the item is not a regular cataloged item shown in the current catalog of the manufacturer.

D. Manufacturer's Recommendations: Where installation procedures of any part thereof are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

B. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. When stored inside, do not exceed structural capacity of the floor.

C. Protect flanges, fittings, and piping specialties from moisture and dirt.

D. Protect stored plastic pipes from direct sunlight. Support to prevent sagging and bending.

1.5 PROTECTION AND CLEANING

A. It shall be this trade's responsibility to store his materials in a manner that will maintain an orderly clean appearance. If stored on-site in open or unprotected areas, all equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.

B. The inlet and discharge openings of all fan coil, VAV Box, Fan Powered Box, and other terminal units shall be kept covered until all local plastering, parging, etc. is completed, and the units are ready to run.

C. Equipment and material if left in the open and damaged shall be repainted, or otherwise refurbished at the discretion of the owner. Equipment and material is subject to rejection and replacement if in the opinion of the engineer, or in the opinion of the manufacturer's engineering department, the equipment has deteriorated or been damaged to the extent that its immediate use is questionable, or that its normal life expectancy has been curtailed.

D. During the erection protect all ductwork, duct lining, insulation, piping, and equipment from damage and dirt. Cap the open top of all ductwork and piping installed vertically.

E. After completion of project, clean the exterior surface of all equipment included in this division of work including, but not limited to, concrete residue.

F. Chemical Cleaning: All piping systems shall be thoroughly flushed out with the approved cleaning chemicals to remove pipe dope, slushing compounds, cutting oils, and other loose extraneous materials. This also includes any piping systems which are not listed as requiring water treatment. The cleaning chemicals shall be added by the mechanical trade. The chemical supplier shall verify that the chemicals are compatible with all the materials in the systems. The chemical supplier shall instruct as to the proper feed rates, shall check that the cleaning solution is actually in each system, shall instruct the contractor as to when to flush the system and shall check each system following flushing to insure all cleaning chemicals have been removed from each system. The mechanical trade shall block open all modulating valves, zone valves and all other system restrictions. If building pumps are not available, this trade shall provide portable pumps to circulate water for cleaning.

G. A certificate of cleaning shall be provided by the cleaning chemical supplier to the Architect's representative.

1.6 FIRE AND SMOKE DETECTION

A. Fire and smoke detection system will be provided and installed by the Electrical trade. The HVAC trade will provide suitable openings (as recommended by the Smoke Detection System Manufacturer) in sheet metal for sensing elements.

B. This Trade will provide access doors to make all such detection heads accessible.

C. This trade will provide bracing for smoke detection sampling tubes which exceed 48" in length.

1.7 SEQUENCING AND SCHEDULING

A. Coordinate mechanical equipment installation with other building components.

B. Arrange for chases, slots, and openings in building structure during progress of construction to allow for mechanical installations.

C. Coordinate the installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

D. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Coordinate installation of large equipment requiring positioning prior to closing in the building.

E. Coordinate connection of electrical services.

F. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies.

G. Coordinate requirements for access panels and doors where mechanical items requiring access are concealed behind finished surfaces. Access panels and doors are specified in Division 8 Section "Access Doors."

H. Coordinate installation of identifying devices after completing covering and painting where devices are applied to surfaces. Install identifying devices prior to installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 CENTRAL CONTROL PANELS

A. Provide panel for alarm and start-stop functions.

B. Provide panel for alarm functions.

C. See drawings for details.

2.2 ACCESS DOORS IN FINISHED CONSTRUCTION

A. Access doors as required for operation and maintenance of concealed equipment, valves, controls, etc will be provided by another trade.

B. This Trade is responsible for access door location, size and its accessibility to the valves or equipment being served.

C. Coordinate and prepare a location, size, and function schedule of access doors

required and deliver to a representative of the installing Trade. Furnish and install distinctively colored ___ buttons in finished ceiling.

D. Access doors shall be of ample size, minimum of 16" x 16".

E. Construct doors and frames to comply with the requirements of the NFPA and Underwriters Laboratories Inc. for fire rating. Install UL label on each door in a non-exposed location unless otherwise required by the local authority having jurisdiction.

2.3 DIELECTRIC FITTINGS

A. Provide dielectric fittings to isolate joined dissimilar materials to prevent galvanic action and stop corrosion. Fittings shall be of the non reducing type, which shall be suitable for the system fluid, pressure, and temperature and shall not restrict the flow.

B. For factory fabricated equipment, manufacturer shall submit method of compliance or exceptions (if applicable) in writing as part of the shop drawings submission for review and approval by Engineer.

C. It is the intent of this section that all system components (equipment connections, piping, etc.). Whether they are field installed or factory fabricated shall comply with paragraph A above.

D. See paragraph, PIPING SPECIALTIES, for additional details.

2.4 PIPE AND PIPE FITTINGS

A. Also refer to individual piping system specification Sections for pipe and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.5 JOINING MATERIALS

A. Refer to individual piping system specification Sections in Division 15 for special joining materials not listed below.

B. Pipe Flange Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3mm) maximum thickness, except where thickness or specific material is indicated.
2. ASME B16.20 for grooved, ring-joint, steel flanges.
3. AWWA C110, rubber, flat face, 1/8 inch (3 mm) thick, except where other thickness is indicated; and full-face or ring type, except where type is indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, except where other material is indicated.

D. Plastic Pipe Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, except where other type or material is indicated.

E. Solder Filler Metal: ASTM B 32.

F. Fittings for copper tubing shall be Chase Sweat Fittings, Mueller Brass Co.'s "Streamline" solder fittings, or "Arco" wrought-copper fittings. "T"-Drill type fittings are not acceptable. All piping shall be installed in a workmanlike manner, according to the manufacturer's instruction. All joints shall be thoroughly cleaned before connecting. All solder for copper tubing shall have a melting point of not less than 460 degrees F., composed of 95% tin and 5% antimony, or brazing filler metal melting at or above 1000°F (silver or copper-phosphorus) in accordance with the following table. Regardless of pressures in table below, use 95-5 tin antimony for fresh water.

SAFE STRENGTH OF SOLDERED JOINTS
Pressure Ratings
Maximum Service Pressure, PSI
Water

Solder used in Joints	Service Tempera-tures Deg. F.	1/4 to 1 inch Incl.	1-1/4 to 2 inches Incl.	2-1/2 to 4 inches Incl.	6 inches
95-5 Tin-Antimony	100	500	400	300	260
	150	400	350	275	260
	200	300	250	200	250
	250	200	175	150	250
Brazing Filler Metal* at or above 1000°F	250	300	210	170	150
	350	270	190	155	150

* For service temperatures 200° and below, the rated internal pressure is equal to that of tube being joined.

G. Brazing Filler Metals: AWS A5.8.
1. BCuP Series: Copper-phosphorus alloys.
2. BAg1: Silver alloy.

H. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

I. Solvent Cements: Manufacturer's standard solvents complying with the following:
1. Acrylonitrile-Butadiene-Styrene (ABS): ASTM D 2235.
2. Chlorinated Poly(Vinyl Chloride) (CPVC): ASTM F 493.
3. Poly(Vinyl Chloride) (PVC): ASTM D 2564.
4. PVC to ABS Transition: Made to requirements of ASTM D 3138, color other than orange.

J. Plastic Pipe Seals: ASTM F 477, elastomeric gasket.

K. Flanged, Ductile-Iron Pipe Gasket, Bolts, and Nuts: AWWA C110, rubber gasket,

carbon steel bolts and nuts.

L. Couplings: Iron body sleeve assembly, fabricated to match outside diameters of plain-end pressure pipes.

1. Sleeve: ASTM A 126, Class B, gray iron.
2. Followers: ASTM A 47 (ASTM A 47M), Grade 32510 or ASTM A 536 ductile iron.
3. Gaskets: Rubber.
4. Bolts and Nuts: AWWA C111.
5. Finish: Enamel paint.

2.6 PIPING SPECIALTIES

A. Provide escutcheons on all exposed piping passing through walls, floors, partitions and ceilings, except provide close fitting metal escutcheons on both sides of piping (whether exposed or not) through required fire rated walls, floors, partitions & ceilings.

B. Escutcheons: Manufactured wall, ceiling, and floor plates; deep-pattern type where required to conceal protruding fittings and sleeves.
1. Inside Diameter: Closely fit around pipe, tube, and insulation.
2. Outside Diameter: Completely cover opening.
3. Cast Brass: One-piece, with set-screw.

C. Dielectric Fittings: Assembly or fitting, non-reducing type, having insulating material isolating joined dissimilar metals to prevent galvanic action and stop corrosion.
1. Description: Combination of copper alloy and ferrous; threaded, solder, plain, and weld neck end types and matching piping system materials.

2. Insulating Material: Suitable for system fluid, pressure, and temperature, does not restrict flow.

3. Dielectric Unions: Factory-fabricated, union assembly for 250-psig (1725kPa) minimum working pressure at a 180 deg F (82 deg C) temperature.

4. Dielectric Flanges: Factory-fabricated, companion-flange assembly for 150- or 300-psig (1035kPa or 2070kPa) minimum pressure to suit system pressures.

5. Dielectric-Flange Insulation Kits: Field-assembled, companion-flange assembly, full-face or ring type. Components include neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

6. Dielectric Couplings: Galvanized-steel coupling, having inert and noncorrosive, thermoplastic lining, with threaded ends and 300-psig (2070kPa) minimum working pressure at 225 deg F (107 deg C) temperature.

7. Dielectric Nipples: Electroplated steel nipple, having inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved end types and 300-psig (2070kPa) working pressure at 225 deg F (107 deg C) temperature.

D. Mechanical Sleeve Seals: Modular, watertight mechanical type. Components include interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve. Connecting bolts and pressure plates cause rubber sealing elements to expand when tightened.

E. Sleeves: The following materials are for all wall, floor, slab, and roof penetrations:

F. Sleeve Materials

Type Designation	Sleeve Material
1	#18 gauge, galvanized steel.
2	Standard weight galvanized steel pipe.
3	Standard weight galvanized steel pipe with a continuously welded water stop of 1/4" steel plate extending from outside of sleeve a minimum of 2" all around - similar to F & S Mfg. Corp. Fig. 204.
4	Cast iron pipe sleeve with center flange - similar to James B. Clow & Sons No. F-1430 and F-1435.
5	Standard weight galvanized steel pipe with flashing clamp device welded to pipe sleeve or watertight sleeves - similar to Zurn 195-10 with oakum caulking as required.
6	Metal deck and wall sleeves similar to Adjust-To-Crete Mfg. Co.

G. Sleeve Sizes

1. Floors and required fire rated partitions - ½" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

2. Partitions not fire rated - 1-1/2" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

H. Sleeve Lengths

Location	Sleeve Length
Floors	Equal to depth of floor construction including finish. In waterproof floor construction sleeves to extend minimum of 2" above finished floor level.
Roofs	Equal to depth of roof construction including insulation.
Walls & Partitions	Equal to depth of construction and terminated flush with surfaces.

I. Sleeve Caulking & Packing.

Type Designation	Caulking & Packing Requirements
A	Space between pipe and sleeve packed with oakum or hemp and caulked watertight.
B	Space between pipe or pipe covering and sleeve shall be caulked with an incombustible, permanently plastic, waterproof non-staining compound leaving a finished smooth appearance or pack with mineral wool or other equally approved fire resistive material to within ½" of both wall faces and provide caulking compound as per above.

2.7 IDENTIFYING DEVICES AND LABELS

A. General: Manufacturer's standard products of categories and types required for each application as referenced in other Division 15 Sections. Where more than one type is specified for listed application, selection is Installer's option, but provide single selection for each product category.

B. Equipment Nameplates: Metal nameplate with operational data engraved or stamped, permanently fastened to equipment.

1. Data: Manufacturer, product name, model number, serial number, capacity,

operating and power characteristics, labels of tested compliances, and similar essential data.

2. Location: An accessible and visible location.

C. Stencils: Standard stencils, prepared for required applications with letter sizes conforming to recommendations of ASME A13.1 for piping and similar applications, but not less than 1-1/4-inch (30mm) -high letters for ductwork and not less than 3/4-inch (19mm) -high letters for access door signs and similar operational instructions.

1. Material: Fiberboard.

2. Stencil Paint: Standard exterior type stenciling enamel; black, except as otherwise indicated; either brushing grade or pressurized spray-can form and grade.

3. Identification Paint: Standard identification enamel of colors indicated or, if not otherwise indicated for piping systems, comply with ASME A13.1 for colors.

D. Pressure-Sensitive Pipe Markers: Manufacturer's standard preprinted, permanent adhesive, color-coded, pressure-sensitive vinyl pipe markers, conforming to ASME A13.1.

E. Plastic Duct Markers: Manufacturer's standard laminated plastic, color coded duct markers. Conform to following color code:

1. Green: Cold air.
2. Yellow: Hot air.
3. Yellow/Green: Supply air.
4. Blue: Exhaust, outside, return, and mixed air.
5. For hazardous exhausts, use colors and designs recommended by ASME A13.1.
6. Nomenclature: Include following:

F. Engraved Plastic-Laminate Signs: ASTM D 709, Type I, cellulose, paper-base, phenolic-resin-laminate engraving stock; Grade ES-2, black surface, black phenolic core, with white (letter color) melamine subcore, except when other colors are indicated.

1. Fabricate in sizes required for message.
2. Engraved with engraver's standard letter style, of sizes and with wording to match equipment identification.
3. Punch for mechanical fastening.
4. Thickness: 1/8 inch (3 mm), except as otherwise indicated.
5. Fasteners: Self-tapping stainless-steel screws or contact-type permanent adhesive.

G. Plastic Equipment Markers: Laminated-plastic, color-coded equipment markers. Conform to following color code:

1. Green: Cooling equipment and components.
2. Yellow: Heating equipment and components.
3. Yellow/Green: Combination cooling and heating equipment and components.
4. Brown: Energy reclamation equipment and components.
5. Blue: Equipment and components that do not meet any of the above criteria.
6. For hazardous equipment, use colors and designs recommended by ASME A13.1.
7. Nomenclature: Include following, matching terminology on schedules as closely as possible:
8. Size: Approximately 2-1/2 by 4 inches (65 by 100 mm) for control devices, dampers, and valves; and 4-1/2 by 6 inches (115 by 150 mm) for equipment.

H. Lettering and Graphics: Coordinate names, abbreviations, and other designations used in mechanical identification, with corresponding designations indicated. Use numbers, lettering, and wording indicated for proper identification and operation/maintenance of mechanical systems and equipment.
1. Multiple Systems: Where multiple systems of same generic name are indicated, provide identification that indicates individual system number as well as service such as "Boiler No. 3," "Air Supply No. 1H," or "Standpipe F12."

2.8 GROUT

A. Nonshrink, Nonmetallic Grout: ASTM C 1107, Grade B.
1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.50MPa), 28-day compressive strength.
3. Packaging: Premixed and factory-packaged.

2.9 DRIVE GUARDS

A. For all machinery and equipment provide guards for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor.

B. Materials: Sheet steel, cast iron, expanded metal or heavy gauge wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

C. Access for Speed Measurement: One inch diameter hole at each shaft center.

2.10 ELECTRICAL MOTORS, MOTOR CONTROLS, AND WIRING

A. For all work required in conjunction with electrical motors, motor controls, and wiring, see complete delineation on the drawings under the title of "List of Electric Motors and Motor Controls" and the notes pertaining to same. Note that all motors, starters & motor control centers are purchased by the HVAC Trade. Motors for equipment shall be provided by the Equipment Manufacturer. All equipment shall have U.L. label where obtainable.

B. See “Automatic Controls” for separation of work for control wiring between Electrical and HVAC trades.

2.11 FIRE-STOPPING

A. Refer to Section, FIRESTOPPING.

B. HVAC trade is responsible for firestopping of HVAC work.

C. Firestopping system must be U.L. approved.

D. All spaces between ducts or pipes and their respective sleeves shall be packed full depth with mineral wool, or other equally approved fire resistant material, and compressed firmly in place. Fiberglass shall not be used. Sleeve clearances shall not exceed ½ inch between pipes (or ducts) and sleeves. Use individual sleeves for each pipe or duct. Use escutcheons on both sides of sleeves. This includes spaces between ducts on pipes and their respective sleeves or openings at fan rooms (whether walls are fire rated or not).

2.12 TOOLS AND LUBRICANTS

A. Furnish special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Lubricants: A minimum of one quart of oil, and one pound of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.13 DAMPERS - GENERAL

A. All electric and/or pneumatic operated dampers which have a fire and/or smoke rating shall be furnished by the mechanical contractor. All other electric and/or pneumatic operated dampers shall be furnished by the Controls (ATC/BMS) Contractor. Fusible link dampers for fire protection, manual dampers for balancing and/or shut-off as well as dampers which are specified as part of factory built air handling units or terminal units shall be furnished by the mechanical contractor. All dampers shall be installed by the mechanical contractor.

B. Type “B” or “C” mountings shall be used for all dampers. Type “A” mountings are not permitted. All dampers are to be selected and installed so that the frames, stops, etc. are located outside of the airstream so as to provide a nominal 100% free area damper.

C. The mechanical contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The actuators shall be located outside of the airstream. The mechanical contractor shall provide a terminal strip alongside the damper for all dampers he furnishes.

D. The controls contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The actuators shall be located outside of the airstream. The controls contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

E. Wiring for motor operated dampers that have a fire and/or smoke rating shall be provided by the mechanical trade from the damper actuator and any associated end switches and sensors to a terminal strip that is wall mounted along side the damper.

F. The controls contractor shall provide wiring as follows:

1. Between the central control system **[BMS]** and the terminal strip for all dampers monitored and/or controlled by the **[BMS][ATC]** whether or not the controls contractor has furnished the damper.

2. Between the terminal strip for all dampers and their associated thermostats, pressure switches, etc. whether or not the control contractor has furnished the damper.

G. Dampers incorporating multiple sections shall be controlled in unison. Where more than one (1) actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly.

H. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement.

I. The following table summarizes the trade responsibilities with respect to automatic dampers:

Description	*Non-Fire or Smoke Rated Dampers*	*Fire and/or Smoke Rated Dampers not Controlled by Fire Alarm System*	*Fire and/or Smoke Rated Dampers Controlled by Fire Alarm System*
Furnish Damper	Controls Contractor	Mechanical Trade	Mechanical Trade

Description	*Non-Fire or Smoke Rated Dampers*	*Fire and/or Smoke Rated Dampers not Controlled by Fire Alarm System*	*Fire and/or Smoke Rated Dampers Controlled by Fire Alarm System*
Install Damper	Mechanical Trade	Mechanical Trade	Mechanical Trade
Furnish Actuator(s)	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Actuator(s)	Mechanical Trade	Mechanical Trade	Mechanical Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring between actuator, end switches, heat sensors, and terminal strip	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring from central control system (BMS) to damper terminal strip.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from FAS to damper terminal strip.	Controls Contractor	Controls Contractor	Electrical Trade
Furnish 120V main power to electrical actuators (see notes below)	Controls Contractor	Controls Contractor	Electrical Trade
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contractor	Controls Contractor	Controls Contractor

NOTES

1. Controls contractor shall have overall responsibility for the complete coordination of the work and the operation of the damper/actuator installation.

2. In mechanical rooms 120V power circuits will be provided from an emergency distribution board. These circuits will be terminated in a junction box located in each associated mechanical room and shall be used by the controls contractor to supply local control panels and critical equipment.

   These circuits will also be used by the electrical trade to supply dampers, etc. , requiring control by the Fire Alarm System. Final connection from the terminal strips to the actuators, end switches and sensors shall be by the mechanical trade.

3. For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from either the emergency circuits as detailed above or from the motor starter terminal trip. All wiring shall be by the controls contractor.

2.14 DAMPER TERMINAL STRIPS

A. Terminal strip(s) shall be provided along side all motorized dampers. If the damper has a smoke and/or fire rating, the terminal strip shall be provided by the Mechanical Trade. If the damper does not have a fire and/or smoke rating then the terminal strip shall be provided by the controls contractor.

B. Where dampers are furnished by the controls contractor then he shall provide relays, interconnect wiring and other components to meet the requirements detailed below. The terminal strip(s), relays, etc. shall be housed in wall mounted enclosures which meet the specifications detailed for local starter enclosures.

C. The terminal strip shall be wired such that the Central Control System (ATC/BMS) can undertake the following control and monitoring functions:

   1. Open Control - A pair of terminals shall be wired such that when a controls (ATC/BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. This signal from the Central Control System (ATC/BMS) shall be overridden by a close signal from the Fire Alarm System (FAS) Where dampers are interlocked to motors then the wiring shall be to these terminals.

   2. Close Control - A pair of terminals shall be wired such that when a controls (ATC/BMS) relay closes a contact pair across these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used. This signal from the Central Control System (ATC/BMS) shall be overridden by an open signal from the FAS.

   3. Motor Interlock - A pair of terminals shall be wired to an end switch on the actuator such that the contacts between the terminals shall be closed when the damper is fully open and open when the damper is not fully open. This pair of terminals shall be used for interlocking a damper with a motor such that the motor will not be able to start if the damper is not fully open.

D. Purge Dampers

For each damper which is to be monitored and/or controlled by the Fire Alarm System (FAS), the damper actuator, heat sensor and end switches shall each be wired by the mechanical trade to a terminal strip(s) mounted adjacent to the damper so that the FAS can undertake the following control and monitoring functions:

1. FAS "Open/Close" Control - The damper will be driven open in response to closure of an FAS relay contact and will spring closed in response to opening of this relay contact.

2. FAS "Override Open" Control (Smoke Purge Dampers Only) - The damper will be re-opened, subsequent to a heat sensor initiated closure, in response to closure of a second FAS relay contact (or reclosure of the first contact for single sensor dampers).

3. FAS "Open/Closed" Status Monitoring Control (Smoke Purge Dampers Only) - End Switch closures will cause activation of FAS "opened" and "closed" relays in response to operation of end switches at both ends of travel.

4. FAS "Override of ATC (BMS)" Control - For each damper requiring both FAS and ATC (BMS) control, the Controls Contractor shall mount an interface relay within 30 circuiting feet of the damper terminal strip, so wired as to permit FAS override of the ATC (BMS) control.

E. The controls contractor's damper manufacturer shall provide all necessary wiring diagrams to the FAS contractors.

F. Dampers furnished by the mechanical trade shall have similar terminal strips to which the controls contractor shall wire where necessary.

G. Comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (ATC/BMS) terminals.

2.15 AUTOMATIC CONTROL VALVES - GENERAL

A. All automatic control valves controlled by the central control system (ATC/BMS) shall be furnished by the controls contractor unless noted otherwise in these documents.

B. All automatic control valves shall be installed by the mechanical trade.

C. The controls contractor shall provide wiring as follows:

1. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.

2. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.

3. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.

D. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (ATC/BMS) terminals.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS--COMMON REQUIREMENTS

A. General: Install piping as described herein, except where system Sections specify otherwise. Individual piping system specification Sections in Division 15 specify piping installation requirements unique to the piping system.

B. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, except where deviations to layout are approved on coordination drawings.

C. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.

D. Install gages, thermometers, valves and other devices with due regard for ease in reading or operating and maintaining said devices. Locate and position thermometers and gages to be easily read by operator or staff standing on floor or walkway provided. Servicing shall not require dismantling adjacent equipment or pipe work.

E. Furnish and install all necessary float devices, aquastats, thermostats, pressure sensors, etc. required for alarm indication as indicated on the HVAC Motor Controls Specifications sheet.

F. Install piping at required slope.

G. Install components having pressure rating equal to or greater than system operating pressure.

H. Install piping in concealed interior and exterior locations, except in equipment rooms and service areas.

I. Install piping free of sags and bends.

J. Install exposed interior and exterior piping at right angles or parallel to building walls. Diagonal runs are prohibited, except where indicated.

K. Install piping tight to slabs, beams, joists, columns, walls, and other building elements. Allow sufficient space above removable ceiling panels to allow for ceiling panel removal.

L. Install piping to allow application of insulation plus 1-inch (25mm) clearance around insulation.

M. Locate groups of pipes parallel to each other, spaced to permit valve servicing.

N. Install fittings for changes in direction and branch connections.

O. Install couplings according to manufacturer's printed instructions.

P. Install pipe escutcheons for pipe penetrations of concrete and masonry walls, wall board partitions, and suspended ceilings according to the following:

1. Chrome-Plated Piping: Cast-brass, one-piece, with set-screw, and polished chrome-plated finish. Use split-casting escutcheons, where required, for existing piping.

2. Uninsulated Piping Wall Escutcheons: Cast-brass or stamped-steel, with set-screw.

3. Uninsulated Piping Floor Plates in Utility Areas: Cast-iron floor plates.

4. Insulated Piping: Cast-brass or stamped-steel, with concealed hinge, spring clips, and chrome-plated finish.

5. Piping in Utility Areas: Cast-brass or stamped-steel, with set-screw or spring clips.

Q. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, concrete floor and roof slabs, and where indicated.

1. Cut sleeves to length for mounting flush with both surfaces.

2. Build sleeves into new walls and slabs as work progresses.

R. Sleeve Application

Sleeve Type Thru Required Fire Rated Construction	Sleeve Type Thru Non-Fire Rated Construction	Location	Sleeve Caulking & Packing Type Designation
5	5	Membrane waterproof floor, roof and wall construction	B Note: Another trade will carry membrane up around sleeve and down inside sleeve
5	5	Non membrane waterproof floor, roof and wall construction where flashing is required	A or B
2	1,2	Interior walls, partitions and floors	B
3 or 4	3 or 4	Exterior walls	A
2	6	Metal deck floors	B
1	1	Precast concrete floor with poured concrete topping. Note: Sleeves to have flat flanges and/or guides which rest on top of precast slab	B

S. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestopping sealant material. Firestopping materials are specified in Division 7 Section "Firestopping."

T. Verify final equipment locations for roughing in.

U. Refer to equipment specifications in other Sections for roughing-in requirements.

V. Piping Joint Construction: Join pipe and fittings as follows and as specifically required in individual piping system Sections.

1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

2. Remove scale, slag, dirt, and debris from inside and outside of pipe and

fittings before assembly.

3. Soldered Joints: Construct joints according to AWS "Soldering Manual," Chapter 22 "The Soldering of Pipe and Tube."

4. Brazed Joints: Construct joints according to AWS "Brazing Manual" in the "Pipe and Tube" chapter.

5. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full inside diameter. Join pipe fittings and valves as follows:

6. Welded Joints: Construct joints according to AWS D10.12 "Recommended Practices and Procedures for Welding Low Carbon Steel Pipe" using qualified processes and welding operators according to the "Quality Assurance" Article.

7. Flanged Joints: Align flange surfaces parallel. Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly using torque wrench.

8. Plastic Pipe and Fitting Solvent-Cement Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join pipe and fittings according to the following standards:

9. Plastic Pipe and Fitting Heat-Fusion Joints: Prepare pipe and fittings and join with heat-fusion equipment according to manufacturer's printed instructions.

W. Piping Connections: Except as otherwise indicated, make piping connections as specified below.

1. Install unions in piping 2 inches (50 mm) and smaller adjacent to each valve and at final connection to each piece of equipment having a 2-inch (50mm) or smaller threaded pipe connection.

2. Install flanges in piping 2-1/2 inches (65 mm) and larger adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.

3. Wet Piping Systems (Water and Steam): Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

X. All welding elbows shall be long radius elbows as manufactured by Tube Turn, ANSI B16.9.

Y. Where welding is used, fittings shall be Tube Turn, Bonney Forge, Taylor Forge, Ladish, or other approved manufacture, ANSI B-16.9. Welding end fittings shall

have the same bursting pressure as pipe of the same size and schedule. Tee fittings shall be one piece except that weldolets are permitted where branches are at least one pipe size less than the main.

Z. All cast iron fittings shall be Stockham, Grinnell, or other approved.

3.2 PRESSURE TESTING - ALL PIPING SYSTEMS

A. Water shall not be introduced into piping systems for testing without water treatment. All piping systems shall be tested to a hydrostatic pressure at least 1-1/2 times the maximum operating pressure (but not less than 40 lbs. per sq. in.) for a sufficiently long time, but not less than 4 hours, to detect all leaks and defects. Where necessary, piping shall be tested in sections to permit the progress of the job.

B. Hydrostatic Testing Corrosion Inhibitor

1. If sections of system must be hydrostatically tested prior to cleanout, appropriate inhibitor shall be added to the test water at sufficient level to totally passivate metal and provide protective film on pipe surfaces to prevent corrosion prior to cleanout and treatment.

2. Mechanical Contractor shall be responsible to coordinate this treatment with the water treatment contractor. At no time shall the Mechanical Contractor add water to a system without treatment.

3.3 EQUIPMENT INSTALLATION--COMMON REQUIREMENTS

A. Install equipment to provide the maximum possible headroom where mounting heights are not indicated.

B. Install equipment according to approved submittal data. Portions of the Work are shown only in diagrammatic form. Refer conflicts to the Architect.

C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, except where otherwise indicated.

D. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.

E. Install equipment giving right-of-way to piping systems installed at a required slope.

3.4 LABELING AND IDENTIFYING

A. Piping Systems: Install pipe markers on each system. Include arrows showing normal direction of flow.

1. Stenciled Markers: Complying with ASME A13.1.

2. Plastic markers, with application systems. Install on pipe insulation segment where required for hot noninsulated pipes.

3. On exposed piping apply bands on 30 foot centers of straight runs, at valve locations, at points where piping enters and leaves a partition, wall, floor or ceiling.

4. On concealed piping installed above removable ceiling construction apply bands in manner described for exposed piping.

5. On concealed piping installed above non-removable ceiling construction, or in pipe shafts, apply bands at valve or other devices that are made accessible by means of access doors or panels.

6. Apply bands at exit and entrance points to each vessel, tank or piece of equipment.

7. Band widths shall be 8" for pipes up to 10 inch diameter and 16" wide for larger diameter piping. Letter heights stating service shall be preprinted on band 3/4" high for 8 inch bands and 1-1/2" high for 16 inch bands.

8. For insulated pipes apply bands after insulation and painting work has been completed.

9. Colors shall conform to ASME Standard A13.1. Provide 24 additional bands of each type for future use by Owner's personnel.

10. Follow manufacturer's instructions for application procedures using non-combustible materials and contact adhesives.

B. Equipment: Install engraved plastic laminate sign or equipment marker on or near each major item of mechanical equipment.

1. Lettering Size: Minimum 1/4-inch (6mm) -high lettering for name of unit where viewing distance is less than 2 feet (0.6 m), ½-inch (13mm) -high for distances up to 6 feet (1.8 m), and proportionately larger lettering for greater distances. Provide secondary lettering 2/3 to 3/4 of size of principal lettering.

2. Text of Signs: Provide text to distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to name of identified unit.

C. Duct Systems: Identify air supply, return, exhaust, intake, and relief ducts with duct markers; or provide stenciled signs and arrows, showing duct system service and direction of flow.

1. Location: In each space where ducts are exposed or concealed by removable ceiling system, locate signs near points where ducts enter into space and at maximum intervals of 50 feet (15 m).

D. Adjusting: Relocate identifying devices which become visually blocked by work of this Division or other Divisions.

E. Valves

1. Attach a 2" round brass tag stamped with designating numbers 1" high filled in with black enamel to each valve, except those on fixtures.

2. Securely fasten valve tag to valve spindle or handle with a brass chain.
3. Provide approved ceiling tile markers in areas where removable ceilings occur to indicate location of valves or other devices.

F. Motor Control Identification

1. Mount black lamacoid nameplates on each motor controller identifying primary control function and individual position indication such as Pump No. 1, etc. Nameplates shall be cut through to white background and have beveled edges. Mount with chromium plated acorn head screws.

G. Schedules and Charts

1. Furnish to Owner's Representative three (3) complete framed plastic laminated valve tag schedules. Schedule shall indicate tag number, valve location by floor and nearest column number, valve size and service controlled.

3.5 PAINTING AND FINISHING

A. Refer to Division 9 Section "Painting" for field painting requirements.

B. Damage and Touch Up: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.6 PANS AND DRAINS OVER ELECTRICAL EQUIPMENT:

A. This contractor shall examine the drawings and in cooperation with the Electrical Trade confirm the final location of all electrical equipment to be installed in the vicinity of piping. Plan and arrange all overhead piping no closer than four feet from a vertical line above electrical equipment, including but not limited to, elevator machine room equipment, main switchgear equipment, motor control centers, starter, electric motors, switchboards, panelboards, or similar equipment. Piping is not permitted in Electric Equipment, Transformer, Switch Gear, Elevator Equipment, Telephone Gear Rooms.

B. Where the installation of piping does not comply with the requirements of the foregoing paragraph, where feasible the piping shall be relocated.

C. Furnish gutters as follows:

1. Provide and erect a gutter of 16 ounce cold rolled copper or 18 gauge galvanized steel, under every pipe which is within 4'-0" from a vertical line to any motor, electrical controllers, switchboards, panelboards, or the like.

2. Each gutter shall be reinforced, rimmed, soldered and made watertight, properly suspended and carefully pitched to a convenient point for draining. Provide a 3/4" drain, with valve as directed, to nearest floor drain or slop sink, as approved.

3. In lieu of such separate gutters, a continuous protecting drain pan of similar construction adequately supported and braced, properly rimmed, pitched and drained to a floor drain or suitable waste, may be provided over any such electrical equipment, and extending 3'-0" in all directions beyond the electrical equipment, over which such piping has to run.

3.7 CONCRETE BASES

A. Construct concrete equipment bases of dimensions indicated, but not less than 4 inches (100 mm) larger than supported unit in both directions. Follow supported equipment manufacturer's setting templates for anchor bolt and tie locations. Refer to concrete strength and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete."

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGE

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

B. Field Welding: Comply with AWS D1.1 "Structural Welding Code--Steel."

3.9 GROUTING

A. Install nonmetallic nonshrink grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors. Mix grout according to manufacturer's printed instructions.

B. Clean surfaces that will come into contact with grout.

C. Provide forms for placement of grout, as required.

D. Avoid air entrapment when placing grout.

E. Place grout to completely fill equipment bases.

F. Place grout on concrete bases to provide a smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout according to manufacturer's printed instructions.

3.10 WELDING PROCEDURE

A. Pipe welding shall comply with the provisions of the latest revision of ANSI/ASME B31.9 Building Services Piping, or such state or local requirements as may supersede codes mentioned above.

B. Pipe welding for MPS/HPS (15 psig and above) shall be in accordance with ASME B31.1 Power Piping Code, or such state or local requirements as may supersede codes mentioned above.

C. Before any new pipe welding is performed, submit a copy of welding Procedure Specifications together with proof of its qualification as outlined and required by the most recent issue of the code having jurisdiction.

D. Before any operator shall perform any pipe welding, submit the operator's Qualification Record in conformance with provisions of the code having jurisdiction, showing that the operator was tested under the proven Procedure Specification submitted.

E. Repair or replace any work not in accordance with these specifications.

3.11 EXCAVATION AND BACKFILL

A. All excavation and backfill for HVAC work will be done by the HVAC Trade.

B. The work includes removal of surface improvements, excavating including hand excavation, sheeting, shoring, bracing, maintaining and protecting existing structures, utilities, pavements, shrubbery; dewatering by pumping of all water from excavation, bedding, backfilling, and compacting, restoration of surface improvements and cleaning up of the site.

C. Instructions:

1. Trenches shall be excavated so that pipe can be laid to the alignment and depth indicated on the drawings, and shall be excavated only so far in advance of pipe laying as approved.

2. Width of trenches shall be held to a minimum consistent with the type of material encountered and the size of piping being laid, but the width at the top of the pipe shall not be more than 2 feet plus outside diameter of pipe. Excavation for manholes and other accessories shall have 12 inch minimum and a 24 inch maximum clearance on all sides.

3. Before fill or backfilling commences, all trash, debris, and other foreign material shall be removed from trenches to be backfilled by this Trade. Fill material shall be free from timber, rocks 3" or larger, organic material, frozen material, and other unsuitable material as determined by the Architect. Filling shall not be done in freezing weather, unless specifically approved. No filling shall be done when material already in place is frozen.

4. In filling around pipe, deposit backfill material in successive horizontal layers not exceeding 6" in thickness before compaction. Compact each layer thoroughly by means of approved mechanical tampers. Tech special care to obtain compaction under pipe haunches. Deposit backfill adjacent to pipes on both sides to approximately same elevation at the same time. Continue this method of filling and compacting until backfill is at least 18" above top of pipe.

5. Backfilling for the remainder of pipe trenches to subgrades of paved or landscaped areas shall be done by mechanical tamping and rolling equipment, except that the use of such equipment is prohibited when said use may result in damage to pipelines or structures.

6. All copper tubing laid in ground shall be backfilled around and one (1) foot over with good clean earth, free from stone or cinders, carefully tamped under and around the tubing for its full length. The remainder of the backfill shall be free from stones larger than (3) inches in diameter and shall be satisfactorily compacted by puddling and tamping.

7. Backfill shall be moistened as necessary for proper compaction. Water settling of fill will not be permitted.

8. Complete backfilling of pipe trenches as soon as possible after the pipe is laid and tested.

9. Existing pavements, roadways, walkways, curbs and landscaped areas disturbed during the progress of the excavation and backfill work shall be restored to their original condition at no additional cost to the Owner.

10. Backfill shall be compacted to a minimum of 90% of modified AASHO maximum density as defined by ASTM D-1557. Any layer of fill, or portion

thereof, which is not compacted to the required density shall be recompacted until the specified density is achieved, or the layer shall be removed.

END OF SECTION 15050

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. This section is a part of all plumbing sections.

1.2 SUMMARY

A. Work Included:

1. The system shall include but not limited to the following: All plumbing fixtures and accessories, piping, fittings, valves, strainers, pumps, water distribution, gas distribution, water heaters, storm, sanitary, vents, interceptors, gages, thermometers, equipment and piping identification.

B. This Section includes the following:

1. Piping materials and installation instructions common to most piping systems.

2. Transition fittings.

3. Dielectric fittings.

4. Mechanical sleeve seals.

5. Sleeves.

6. Escutcheons.

7. Grout.

8. Mechanical demolition.

9. Equipment installation requirements common to equipment sections.

10. Painting and finishing.

11. Concrete bases.

12. Supports and anchorages.

C. Related Work include the following:

1. Division 2, Section 02200, EARTHWORK.

2. Division 3, Section 03300, CAST-IN PLACE CONCRETE.

3. Division 5, Section 05500, METAL FABRICATIONS.

4. Division 7, Section 07841, FIRESTOPPING.

5. Division 7, Section 07920, SEALANTS AND CAULKING.

6. Division 9, Section 09900, PAINTING.

7. Division 16, ELECTRICAL.

8. Other Sections where applicable.

1.3 CODES, PERMITS AND INSPECTIONS

A. All work shall meet or exceed the latest requirements of all national, state, county, municipal and other authorities exercising jurisdiction over construction work at the project.

B. All required permits, approval and inspection certificates shall be obtained, paid for, and made available at the completion of the work, by the Plumbing Contractor.

C. Installation procedures, methods, and conditions shall comply with the latest requirements of The Federal Occupational Safety and Health Act (OSHA).

D. Prepare and submit to the building owner a set of “as-built” record drawings for approval, in a form acceptable to the building owner.

E. The Contractor shall be responsible for the installation and filing until the installation has been approved by the authorities having such jurisdiction.

F. Prepare and submit to the Engineer a set of “as-built” record drawings for approval, in a form acceptable to the Engineer.

1.4 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from leaks and defects. Any defective materials or workmanship, as well as damage to the work of all trades resulting from same, shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Non-durable replaceable items, such as water filter media, do not require replacement after the date of acceptance. If received in writing, requests to have earlier acceptance dates established for these items will be honored.

E. Certification shall be submitted attesting to the fact that specified performance criteria are met by all items of plumbing equipment.

1.5 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

F. Piping: Pipe, fittings, flanges, valves, controls, hangers, drains, insulation, and items customarily required in connection with the transfer of fluids.

G. By Other Trades: By persons or parties responsible for work at the project other than the party or parties who have been duly awarded the contract for the work of this Trade. In the event that this document is used to acquire work as part of a general construction contract the words “by other trades” shall mean by persons or parties who are not anticipated to be the sub-contractor for this trade working together with the general contractor. In this context the words “by other trades” shall <u>not</u> be interpreted to mean not included in the overall contract.

H. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.

2. CPVC: Chlorinated polyvinyl chloride plastic.

3. PE: Polyethylene plastic.

4. PVC: Polyvinyl chloride plastic.

I. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.

2. NBR: Acrylonitrile-butadiene rubber.

1.6 SUBMITTALS

A. In accordance with Division 1, Section 01330, SUBMITTAL PROCEDURES, furnish the following:

B. Prior to purchasing any equipment or materials, a list of their manufacturers shall be submitted for approval.

C. Prior to assembling or installing the work, the following shall be submitted for approval:

1. Scale drawings indicating insert and sleeve locations if required by Architect or Structural Engineer.

2. Scale drawings showing all piping and duct runs with sizes, elevations and appropriate indication of coordination with other trades. This submission to us shall consist of one (1) original and (6) six prints.

3. Catalog/internet information, factory assembly drawings and field installation drawings as required for a complete explanation and description of all items of equipment.

D. Documents will not be accepted for review unless:

1. They are submitted as a package where they pertain to related items.

2. They are properly marked with service or function, project name, where they consist of catalog sheets displaying other items which are not applicable.

3. They indicate the project name and address along with the Contractor's name, address and phone number.

4. They are properly marked with external connection identification as related to the project where they consist of standard factory assembly or field installation drawings.

E. Shop Drawing Review

1. The purpose of the review of shop drawings is to maintain integrity of the design. Unless the contractor clearly points out changes, substitutions, deletions or any other differences between the submission and the Contract Documents in writing on the Contractor's letterhead, approval by the Engineer or Architect does not constitute acceptance. It is not to be assumed that the engineer has read the text nor reviewed the technical data of a manufactured item and its components except where the Vendor has pointed out differences between his product and the specified model.

2. It is the responsibility of the contractor to confirm all dimensions, quantities, and the coordination of materials and products supplied by him with other trades. Approval of shop drawings containing errors does not relieve the contractor from making corrections at his expense.

3. Substitutions of equipment, systems, materials, must be in accordance with the substitutions section of these specifications and coordinated by the Contractor with his own or other trades which may be involved with the item, such as, but not limited to, equipment substitutions which change electrical requirements, or hanging or support weights or dimensions.

4. Any extra charges or credits which may be generated by other trades due to substitutions will not be accepted unless the Contractor has an agreement in writing with the Owner.

5. Substitutions of equipment, systems, etc. requiring approval of local authorities must comply with such regulations and be filed at the expense of the Contractor (should filing be necessary). Substitutions are subject to approval or disapproval by the Engineer. The Contractor in offering substitutions shall hold the Owner and Engineer harmless if the substituted item is an infringement of patent held by the specified item.

6. Shop drawings shall show all data required by NFPA.

F. Explanation of Shop Drawing Stamp

1. Reviewed indicates that we have not found any reason why this item should not be acceptable within the intent of the documents.

2. Make Corrections Noted indicates that we have found questionable components which if corrected or otherwise explained make the product acceptable.

3. Revise and Resubmit indicates that this item should be resubmitted for approval before further processing.

   (a) If both "Reviewed As Noted" and "Revive and Resubmit" are checked, the resubmittal is for record purposes only.

4. No shop drawing stamp or note shall constitute an order to fabricate or ship. Such notification can only be performed by the Project Manager for Construction, the Contractor scheduling his own work, or the Owner.

G. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Division 1, Section 01400, QUALITY REQUIREMENTS, Paragraph, INSTRUCTIONS, for systems and equipment.

2. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

3. Furnish required number of manuals, in bound form containing data covering capacities, maintenance of operation of all equipment and apparatus. Operating instruction shall cover all phases of control and include the following:

   (a) Performance Curves: For pumps, and similar equipment at the operating conditions.

   (b) Lubrication Schedule: Indicating type and frequency of lubrication required.

   (c) List of Spares: Recommended for normal service requirements.

   (d) Parts List: Identifying the various parts of the equipment for repair and replacement purposes.

   (e) Instruction Books may be standard booklets but shall be clearly marked to indicate applicable equipment.

   (f) Wiring Diagrams: Generalized diagrams are not acceptable, submittal shall be specifically prepared for this Project.

   (g) Automatic Controls: Diagrams and functional descriptions.

4. Where applicable, one set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

H. Product Data: For the following:

1. Transition fittings.

2. Dielectric fittings.

3. Mechanical sleeve seals.

4. Escutcheons.

I. Welding certificates.

1.7 DELIVERY, STORAGE, HANDLING AND PROTECTION

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

C. This trade shall be responsible for its work and equipment until it is tested, has received final inspection and been accepted. Carefully store materials and equipment which are not immediately installed after delivery to site. Close open ends of work with temporary covers or plugs during construction to prevent entry of obstructing material.

D. This trade shall protect work and material of other trades from damage that might be caused by its work or workmen and make good damage thus caused.

1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

1.9 COORDINATION DRAWINGS:

A. Prepare coordination drawings in accordance with Division 1 Section "PROJECT COORDINATION," to a scale of 3/8"=1'-0" or larger; detailing major elements, components, and systems of plumbing equipment and materials in relationship with other systems, installations, and building components in spaces such as typical floor and mechanical rooms. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of piping, equipment, and materials. Include the following:

(a) Planned piping layout, including valve and specialty locations and valve stem movement.

(b) Clearances for servicing and maintaining equipment, including space for equipment disassembly required for periodic maintenance.

(c) Equipment connections and support details.

(d) Exterior wall and foundation penetrations.

(e) Fire-rated wall and floor penetrations.

(f) Sizes and location of required concrete pads and bases.

(g) Clearances as required by Electric Code.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

3. Prepare reflected ceiling plans to coordinate and integrate sprinkler installations, air outlets and inlets, light fixtures, communication systems components and other ceiling-mounted items.

B. Plumbing Coordination Drawings

1. This trade shall add to Coordination Drawings prepared by the HVAC Contractor showing all of the plumbing work (equipment, piping, conduit, etc.) to be installed as part of the work of this section of the specifications.

2. This Trade after showing all of the plumbing work shall forward the reproducible Coordination Drawings to the Electrical Contractor.

3. The sequence of coordination drawings shall be HVAC-PLBG-FP-ELEC-CM.

4. The plumbing Contractor shall attend a series of meetings arranged by the General Contractor/Construction Manage to resolve any real or apparent interferences or conflicts with the work of the other Contractors.

5. The plumbing Contractor shall then make adjustments to his work on the Coordination Drawings to resolve any real or apparent interferences or conflicts.

6. After any real or apparent interferences and conflicts have been incorporated into the Coordination Drawings, the plumbing Contractor shall "sign-off" the final Coordination Drawings.

7. The plumbing Contractor shall not install any of his work prior to "sign-off" of final Coordination Drawings. If the plumbing work proceeds prior to sign-off of Coordination Drawings, any change to the plumbing work to correct the interferences and conflicts which result will be made by the Plumbing Contractor at no additional cost to the project.

8. Coordination Drawings are for the Contractor's and Architects use during construction and shall not be construed as replacing any shop "as-built", or Record Drawings required elsewhere in these Contract Documents.

9. Architect's review of Coordination Drawings shall not relieve Contractor from his overall responsibility for coordination of all work performed pursuant to the Contract or from any other requirements of the Contract.

C. Record Drawings

1. As part of the required plumbing work, a complete set of "as-built" or record drawings shall be made up and delivered to the architect.

2. The drawings shall show:-

(a) All work installed exactly in accordance with the original design.

(b) All installed as a modification or addition to the original design.

(c) The dimensional information necessary to delineate the exact location of all piping runs which are so concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance.

3. Where shop drawings have been prepared and approved, the "as-built" drawings shall be cross referenced to the respective shop drawing.

4. As-built record drawings shall include the updating of all equipment schedule sheets.

5. The record drawings shall be of legible reproducible and durable type.

6. The Contractor shall make arrangements with the Engineer to obtain design drawings on compact diskettes in AutoCad format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates, Inc. and shall be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

7. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect Engineer the drawing layers, colors, etc., of the CAD drawings.

8. "As-built" information shall be submitted as follows:

(a) Drawing files on compact disketts in AutoCad format.

(b) One (1) set of reproducible drawings.

(c) Two (2) sets of plots.

9. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

10. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.

11. This trade shall submit the "as-built" set for approval by the Engineer in a form acceptable to the Engineer.

12. Final acceptance of the fire protection systems by the authority having jurisdiction will not be implemented until "as-built" drawings are on site.

1.10 INTERPRETATION OF THE DRAWINGS AND SPECIFICATIONS

A. As used in the drawings and specifications, certain non technical words shall be understood to have specific meanings as follows:

1. "Furnish"----------Purchase and coordinate deliver to the project site complete with every necessary appurtenance and support.

2. "Install"----------Unload at the coordinated delivery point and time at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project.

3. “Provide"----------"Furnish" and "Install".

B. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item, regardless of whether or not this instruction is explicitly stated as part of the indication or description.

C. It shall be understood that the specifications and drawings are complementary and are to be taken together for a complete interpretation of the work. Where there are conflicts between the drawings and specifications or within the specifications or drawings themselves, the items of higher standard shall govern.

D. No exclusions from, or limitations, in the language used in the drawings or specifications shall be interpreted as meaning that the appurtenances or accessories necessary to complete any required system or item of equipment are to be omitted.

E. The drawings of necessity utilize symbols and schematic diagrams to indicate various items of work. Neither of these have any dimensional significance nor do they delineate every item required for the intended installations. The work shall be installed, in accordance with the diagrammatic intent expressed on the drawings, and in conformity with the dimensions indicated on final architectural and structural working drawings and on equipment shop drawings.

F. No interpretation shall be made from the limitations of symbols and diagrams that any elements necessary for complete work are excluded.

G. Certain details appear on the drawings which are specific with regard to the dimensioning and positioning of the work. These details are intended only for the purpose of establishing general feasibility. They do not obviate field coordination for the indicated work.

H. Information as to the general construction shall be derived from structural and architectural drawings and specifications only.

I. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

J. In the event that extra work is authorized, and performed by this trade, work shown on drawings depicting such work, and/or described by Bulletin is subject to the base building specifications in all respects.

1.11 SEPARATION OF WORK BETWEEN TRADES

A. The Specifications for the overall construction delineate various items of work under separate trade headings. The list below sets forth this delineation to the extent that it affects the Plumbing Work.

B. In the absence of more detailed information, this list shall be taken as a specific instruction to the Plumbing trade to include the work assigned to it.

C. Indications that the Plumbing trade is to perform an item of work mean that it is to perform the work for its own accommodation only, except as specifically noted otherwise.

D. Oth = Other than electrical or mechanical

Plb = Plumbing

FP = Fire Protection

Htg = Heating, Ventilating & Air Conditioning

Elec = Electrical

f = Furnished

I = Installed

p = Provided (furnished and installed)

Item	Oth	Plb	FP	Htg	Elec	Notes
Motor for plumbing equipment		p				
Motor controls for plumbing equipment.		f			I	Specifications and drawings delineate detailed exceptions.
Wiring for plumbing equipment motors and motor controls.					p	Specifications and drawings delineate detailed exceptions.
Temporary heat	p					
Temporary Water	p					
Temporary light and power.	P					
Temporary toilets.	P					
Natural gas piping and valves for gas fired equipment.		P				Final connections by the Plumbing contractor.
Hoisting	p					
Rigging	p					

Item	Oth	Plb	FP	Htg	Elec	Notes
Bracing of building for safe rigging.		p				
Cutting, chasing and patching	p					Cost where due to late installation, or improper coordination of work is the responsibility of the delinquent trade.
Framed slots and openings in walls decks and slabs.	P					
Sleeves through slabs, decks and walls.		P				
Sleeves through membraned and waterproofed slabs, decks and walls.		P				
Waterproof sealing of pipes passing through sleeves.		P				
Waterproof sealing of sleeves through membraned through membraned and water proofed slabs.		P				
Fireproof sealing of excess openings in slabs, decks and fire rated walls.		P				
Excavation and backfill inside buildings.	P					
Excavation and backfill outside buildings.	P					
Keeping site and excavations free from water during construction.	P					To accommodate the overall project.
Fastenings		p				
Supports		p				
Concrete encasement of underground runs.	P					
Subsoil drainage inside building (footing drains)	p					To accommodate overall project.
Venting for gas tranes on gas fired equipment.				p		Complete.
Subsoil drainage outside building (footing drains)	p					To accommodate overall project.
Sewer manholes (interior)		p				Furnishing of covers, associated frames ane other hardware included in the Plumbing Contractor.
Floor drain flashing		p				
Base flashing for roof drains and all piping penetrating roof.	P					
Cap flashing for all piping penetrating roof.		P				

Item	Oth	Plb	FP	Htg	Elec	Notes
Concrete foundations, pads and bases.	P					Furnishing of anchors and vibration mounts included in the Plumbing Contractor.
Concrete (masonry) pits.	P					Plumbing Contractor to furnish sizes and locations.
Pit frames, covers, pumps, and controls.	P					Special covers sewage ejector pumps, sump pump, pumps, controls, covers and frames furnished by the Plumbing Contractors.
Trenches in building foundation.	P					
Field touch up painting of damaged shop coats.		P				
Prime coating hangers and supports.		P				
Rustproofing field cut and assembled iron supporting frames and racks.		P				
Finished painting	p					
Finished wall and ceiling access doors, panels and supporting frames.	P					Supplying list locating all required access doors (none to be less than 16" x 16") Included in Plumbing Contractor.
Cat walks to mechanical equipment.	P					Supplying list of locations where required included in the Plumbing Contractor.
Ladders to equipment and valves.	P					Supplying list of locations where required to be installed by the Plumbing Contractor.
Domestic make-up water piping for heating and air conditioning systems.		P				Final connections included in heating trade.
Toilet Room accessories.	f					Install certain toilet room accessories as required by local trade union jurisdiction.
Window washing machines	p					Required water outlet provided by Plumbing Contractor.
Plumbing fixtures and accessories.		P				
Soap dispensers on plumbing fixtures.		P				
Food service equipment.	P					
Rubbish removal.		P				Where one trade finishes and another installs, the installing trade removes the shipping and packaging materials which accumulate.

Item	Oth	Plb	FP	Htg	Elec	Notes
Special tools for equipment maintenance.		P				
Laboratory casework and equipment.	p					Plumbing Contractor to provide roughing and final connections.
Balance recirculation system(s).		P				Plumbing Contractor to provide equipment and labor.
Garage drainage and venting system to include gasoline and oil interceptor and venting.		P				Pit(s) provided by General Contractor.
Domestic water service from street main, including valve and valve bo. To capped OS&Y valve connection and water meter inside building.		P				
Electric heating cables for pipe tracing.					p	Insulation over heat tracing by Plumber.

E. The Plumbing Contractor is required to supply all necessary supervision and coordination information to any other trades who are to supply work to accommodate the Plumbing installation.

F. Where the Plumbing Trade is required to install items which it does not purchase, it shall include for such items:

1. The co-ordination of their delivery.

2. Their unloading from delivery trucks driven in to any designated point on the property line at grade level.

3. Their safe handling and field storage up to the time of permanent placement in the project.

4. The correction of any damage, defacement or corrosion to which they may have been subjected.

5. Their field assembly and internal connection as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage supporting members and fastenings necessary to adapt them to architectural and structural conditions.

7. Their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

8. Items which are to be installed but not purchased as part of the work of the Plumbing Contractor shall be carefully examined by this trade upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable

scope of work of the Plumbing Contractor will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The work of the Plumbing Contractor shall include all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.12 APPLICABLE PUBLICATIONS:

A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

Reference	Definition
ASTM	American Society for Testing Materials
ASPE	American Society of Plumbing Engineers
NFPA	National Fire Protection Association
UL	Underwriters Laboratories, Inc.
NEMA	National Electrical Manufacturers Assn.
FM	Factory Mutual
USAS	United States of America Standards Institute
ANSI	American National Standards Institute
AWWA	American Water Works Association
F.S.	Federal Specifications, US Government
I.S.O.	Insurance Services Organization
C.S.	Commercial Standards issued by the United States Department of Commerce.
M.S.S.	Manufacturers Standardization Society of the Valve and Fittings Industry
A.G.A.	American Gas Association, Inc.
A.S.H.R.A.E.	American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.
P.D.I.	Plumbing and Drainage Institute
N.S.F.	National Sanitation Foundation
A.S.S.E.	American Society of Sanitary Engineering

I.A.P.M.O. International Association of Plumbing and Mechanical Officials

C.I.S.P.I. Cast Iron Soil Pipe Institute

A.A.S.H.O. American Association of State Highway Officials

1.13 SEISMIC DESIGN

A. This project is located within Seismic Zone___ as mapped in the Building Code. Special provisions are required for the support and restraint of equipment, piping, etc., in the event of earthquake so as to comply with the State Building Code, with supplements.

B. It shall be understood that the requirements of this seismic section are complementary to requirements delineated elsewhere for the support and fastening of equipment, piping, etc. Nothing on the drawings or specifications shall be interpreted as a reason to waive the requirements of this seismic section.

C. Floor mounted equipment shall be provided with approved seismic control devices as required to prevent overturning or sliding. Seismic restraints shall be capable of keeping equipment captive under seismic loads.

D. Ceiling mounted equipment shall be provided with approved seismic control devices as required to maintain the equipment in a captive attitude under seismic loads.

E. The seismic restraint design and construction requirements for equipment and piping incorporated as part of Life Safety Systems shall be such that these systems will remain in place and be functional following a major earthquake, and that the design shall consider lateral drifts between stories as specified by code.

F. All life safety systems whether isolated or not shall be bolted to structure to allow for the required acceleration. Bolt points and diameter of inserts shall be submitted and verified as part of the contractor's submission for each piece of equipment and certified by a licensed structural engineer.

G. Seismically restrain all piping with center bracing or Type II restraining system in accordance with NFPA guidelines to comply with the Building Code.

H. Equipment and piping submittals shall include the following in addition with the requirements delineated elsewhere.

1. Drawings and calculations (certified by a professional engineer) as required to show the number and location of seismic restraints and specified details of restraints including anchor bolts for mountings and maximum load (static plus dynamic expected at each restraint or snubbing device including fastening devices for the seismic restraints which are capable of maintaining equipment in a captive position when subjected to external forces required for life safety equipment as defined by the State Building Code.

2. Drawings, as required to show the number and location of seismic restraints and specific details of restraints including anchor bolts for mountings an maximum load (static plus dynamic at each seismic restraint location).

I. Seismic restraints shall be provided by a company specializing in vibration isolation and seismic restraints with five years minimum experience.

J. All seismic restraints shall be capable of safely accepting external forces required for life safety equipment without failure and shall maintain equipment, piping, etc. in a captive position. Seismic restraints shall not short circuit isolation systems or transmit objectionable vibration or noise, and shall be provided on all equipment as scheduled ion drawings. Calculations by registered structural engineer shall be submitted to verify snubber capabilities for each piece of equipment.

K. For all piping, regardless of size or length of support, all connections to the building structure must be positively made. Connections which depend all or in part on friction for their supporting action are not acceptable.

L. Do not use branch lines to brace main lines.

M. A rigid piping system shall not be braced to dissimilar parts of a building or two dissimilar building systems that may respond in a different mode during an earthquake. Examples: wall and a roof; solid concrete wall and a metal deck with lightweight concrete fill.

N. Provide large enough pipe sleeves through walls or floors to allow for anticipated differential movements.

O. At vertical pipe risers, wherever possible, support the weight of the riser at a point or points above the center of gravity of the riser. Provide lateral guides at the top and bottom of the riser and at intermediate points not to exceed 30' on center.

1.14 SEISMIC CERTIFICATION

A. Provide details for seismic restraint and bracing of equipment and piping. Such details shall be of complete detailed shop drawings based on the contractor's installation techniques, equipment arrangement and the specific routing of the work. The submission of shop drawings shall include all necessary calculations and manufacturer's certifications as required to demonstrate the suitability of the proposed installation. Calculations shall be performed by an approved licensed structural engineer with experience in the field of equipment support and seismic design, who shall be retained by the contractor for this purpose.

B. The supplier of the seismic restraints, braces and other devices shall have had the experience in designing and manufacturing such equipment for not less than 5 years. Responsibility shall include determining the location and sizes of all restrains and braces as required by the contractor's layout and installation drawings, and furnishing of all such devices with installation instructions. The supplier shall provide any necessary field supervision to insure that the seismic control devices are properly installed.

C. Calculations to demonstrate the adequacy of the proposed seismic devices shall be performed by Seismic Designs, Inc. or other approved structural engineering firm under the supervision of a licensed professional engineer having at least 5 years experience in seismic design.

1.15 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from leaks or defects. Any defective materials or workmanship as well as damage to the work of all trades resulting from same shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Certification shall be submitted attesting to the fact that specified performance criteria are met by all items of Plumbing equipment.

1.16 EXAMINATION OF SITE AND CONTRACT DOCUMENTS

A. Before submitting prices or beginning work, throughly examine the site and the Contract Documents.

B. No claim for extra compensation will be recognized if difficulties are encountered which examination of site conditions and Contract Documents prior to executing the Contract would have revealed.

1.17 WORKMANSHIP

A. The entire work provide in this Specification shall be constructed and finished in every aspect in a workmanlike and substantial manner.

B. It is not intended that the Drawings shall show every pipe, fitting and appliance. Plumbing Contractor shall furnish and install all such parts as may be necessary to complete the systems in accordance with the best trade practice.

C. Keep other trades fully informed as to shape, size and position of all openings required for apparatus and give full information to the General Contractor and other trades in a timely manner so that all opening may be built in advance. Furnish and install all sleeves, supports and the like as specified or as required.

D. In case of failure on the part of the Plumbing Contractor to give proper and timely information as required above, he shall do his own cutting and patching or have same done by the General Contractor, but in any case, without extra expense to the Owner.

E. Obtain detailed information from the manufacturers of apparatus as to the proper method of installing and connecting same. Obtain all information from the General Contractor and other trades which may be necessary to facilitate work and completion of the whole project.

1.18 CONTINUITY OF SERVICES

A. Do not interrupt existing services without Owner's Representative approval.

B. Schedule interruptions in advance, according to Owner's Representative instructions. Submit, in writing, with request for interruption, methods proposed to minimize impact on Owner's operations. Interruptions shall also be coordinated with the local fire department.

C. Interruptions shall be scheduled at such times of day and work to minimize impact on Owner's operations.

1.19 QUALITY ASSURANCE:

A. Products Criteria

1. All equipment furnished as part of the work shall comply with the latest editions of all applicable state and municipal "energy codes." Provide certification from the equipment suppliers for all energy-consuming equipment that the equipment fully complies with these codes. Equipment submissions will not be accepted for review unless accompanied by such certification in writing.

2. All equipment and materials shall be new and without blemish or defect.

3. New equipment and materials shall be Underwriters Laboratories, Inc. (U.L.) labeled and/or listed where specifically called for or where normally subject to such U.L. labeling and/or listing services.

4. Asbestos

   (a) All equipment and materials shall be free of asbestos.

5. Electrical equipment and materials shall be products which will meet with the acceptance of the agency inspecting the electrical work. Where such acceptance is contingent upon having the products examined, tested and certified by Underwriters or other recognized testing laboratory, the product shall be examined, tested and certified. Where no specific indication as to the type or quality of materials or equipment is indicated, a first class standard article shall be furnished.

6. It is the intent of these specifications that wherever a manufacturer of a product is specified, and the terms "other approved" or "or approved equal" or "equal" are used, the substituted item must conform in all respects to the specified item. Consideration will not be given to claims that the substituted item meets the performance requirements with lesser construction (such as lesser heat exchange surface, etc.). Performance as delineated in schedules and in the specifications shall be interpreted as minimum performance. In many cases equipment is oversized to allow for pick-up loads which cannot be delineated under the minimum performance.

7. All equipment of one type such as drains, pumps, fixtures, etc. shall be the products of one Manufacturer.

8. Substituted equipment or optional equipment where permitted and approved, must conform to space requirements. Any substituted equipment that cannot meet space requirements, whether approved or not, shall be replaced at the Contractor's expense. Any modifications of related systems as a result of substitutions shall be made at the Contractor's expense.

9. Note that the approval of shop drawings, or other information submitted in accordance with the requirements hereinbefore specified, does not assure that the Engineer, Architect, or any other Owner's Representative, attests to the dimensional accuracy or dimensional suitability of the material or equipment involved or the ability of the material or equipment involved or the mechanical performance of equipment. Approval of Shop Drawings does not invalidate the plans and specifications if in conflict, unless a letter requesting such change is submitted and approved on the Engineer's letterhead.

10. Substitutions of equipment for that shown on the schedules or designated by model number in the specifications will not be considered if the item is not a regular cataloged item shown in the current catalog of the manufacturer.

11. Prohibition of Lead

    (a) The presence and use of lead is strictly prohibited in potable water systems.

    (b) Potable water shall not be subject to contact with lead in any form.

    (c) The design and manufacture of all materials and equipment (piping, fittings, joints, connections, solders, fixtures, accessories, etc.) provided, shall not contain lead in any form.

    (d) Contractor shall be responsible for all costs involved in testing and certifying that potable water systems, materials and equipment are lead free.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, the manufacturers specified.

2.2 PIPE, TUBE, AND FITTINGS

A. Refer to individual Division 15 piping Sections for pipe, tube, and fitting materials and joining methods.

B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.3 JOINING MATERIALS

A. Refer to individual Division 15 piping Sections for special joining materials not listed below.

B. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch (3.2-mm) maximum thickness unless thickness or specific material is indicated.

(a) Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.

(b) Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. AWWA C110, rubber, flat face, 1/8 inch (3.2 mm) thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.

C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.

G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

H. Solvent Cements for Joining Plastic Piping:

1. CPVC Piping: ASTM F 493.

2. PVC Piping: ASTM D 2564. Include purple primer according to ASTM F 656.

2.4 TRANSITION FITTINGS

A. AWWA Transition Couplings: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.

1. Manufacturers:

(a) Cascade Waterworks Mfg. Co.
(b) Dresser Industries, Inc.; DMD Div.
(c) Ford Meter Box Company, Incorporated (The); Pipe Products Div.
(d) JCM Industries.
(e) Smith-Blair, Inc.
(f) Viking Johnson.

2. Underground Piping NPS 1-1/2 (DN 40) and Smaller: Manufactured fitting or coupling.

3. Underground Piping NPS 2 (DN 50) and Larger: AWWA C219, metal sleeve-type coupling.

4. Aboveground Pressure Piping: Pipe fitting.

B. Plastic-to-Metal Transition Fittings: CPVC and PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.

1. Manufacturer:

(a) Eslon Thermoplastics.

C. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

1. Manufacturers:

(a) Cascade Waterworks Mfg. Co.
(b) Fernco, Inc.
(c) Mission Rubber Company.
(d) Plastic Oddities, Inc.

2.5 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig (1725-kPa) minimum working pressure at 180 deg F (82 deg C).

1. Manufacturers:

(a) Capitol Manufacturing Co.
(b) Central Plastics Company.
(c) Eclipse, Inc.
(d) Epco Sales, Inc.
(e) Hart Industries, International, Inc.
(f) Watts Industries, Inc.; Water Products Div.
(g) Zurn Industries, Inc.; Wilkins Div.

D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig (1035- or 2070-kPa) minimum working pressure as required to suit system pressures.

1. Manufacturers:

(a) Capitol Manufacturing Co.
(b) Central Plastics Company.
(c) Epco Sales, Inc.
(d) Watts Industries, Inc.; Water Products Div.

E. Dielectric-Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.

1. Manufacturers:

(a) Advance Products & Systems, Inc.
(b) Calpico, Inc.
(c) Central Plastics Company.
(d) Pipeline Seal and Insulator, Inc.

2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig (1035- or 2070-kPa) minimum working pressure where required to suit system pressures.

F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Manufacturers:

(a) Calpico, Inc.
(b) Lochinvar Corp.

G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig (2070-kPa) minimum working pressure at 225 deg F (107 deg C).

1. Manufacturers:

(a) Perfection Corp.
(b) Precision Plumbing Products, Inc.
(c) Sioux Chief Manufacturing Co., Inc.
(d) Victaulic Co. of America.

2.6 MECHANICAL SLEEVE SEALS

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Manufacturers:

(a) Advance Products & Systems, Inc.
(b) Calpico, Inc.
(c) Metraflex Co.
(d) Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.

3. Pressure Plates: Stainless steel Include two for each sealing element.

4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.7 SLEEVES

A. General

1. Provide sleeves for each pipe passing through walls, partitions, floors, and roofs.

B. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

C. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

D. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with

plain ends and integral waterstop, unless otherwise indicated.

E. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

F. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

G. PVC Pipe: ASTM D 1785, Schedule 40.

H. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.

I. Sleeve Materials

Type Designation	
1	Galvanized steel sheet.
2	Standard weight galvanized steel pipe.
3	Standard weight galvanized steel pipe 1/4" steel plate extending from outside of sleeve a minimum of 2" all around, similar to F&S Mfg. Corp. Fig. 204.
4	Cast iron pipe sleeve with center flange, similar to James B. Clow & Sons No. F-1430 and F-1435.
5	Standard weight galvanized steel pipe with flashing clamp device welded to pipe sleeve or watertight sleeves, similar to Zurn 195-10 with oakum and lead caulking as required.
6	Metal deck and wall sleeves. Similar to Adjust-to-Crete Manuf., Co.

J. Sleeve Sizes

1. Floors and required fire rated partitions - ½" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

2. Partitions not fire rated - 1-1/2" maximum clearance between outside of pipe (or insulation on insulated pipes) and inside of sleeve.

K. Sleeve Lengths

Location	Sleeve Length
Floors	Equal to depth of floor construction including finish. In waterproof floor construction sleeves to extend minimum of 2" above finished floor level.
Roofs	Equal to depth of roof construction including insulation.
Walls & Partitions	Equal to depth of construction and terminated flush with finished surfaces.

L. Sleeve Caulking & Packing

Type Designation	Caulking & Packing Requirements
A	Space between pipe and sleeve packed with oakum or hemp and caulked watertight with lead.
B	Space between pipe or pipe covering and sleeve shall be caulked with an incombustible permanently plastic, waterproof non-staining smooth appearance or pack with mineral wool or other equally approved fire resistive material to within ½" of both wall faces and provide caulking compound as per above.

M. Sleeve Application

Sleeve Type Thru Required Fire Rated Construction	Sleeve Type Thru Non-Fire Rated Construction	Location	Sleeve Caulking & Packing Type Designation	Sleeve Caulking & Packing Type Thru Fire Rated Construction
5	5	Membrane waterproof floor,roof & wall construction.	B	B

Sleeve

Sleeve Type Thru Required Fire Rated Construction	Sleeve Type Thru Non-Fire Rated Construction	Location	Sleeve Caulking & Packing Type Designation	Caulking & Packing Type Thru Fire Rated Construction
5	5	Non-membrane waterproof floor, roof & wall construction where flashing is required.	A or B	B
2	1, 2	Interior walls, partitions & floors.	B	B
3 or 4	3 or 4	Exterior walls.	A	A
2	6	Cellular metal deck floors.	B	B
1	1	Precast concrete floor with poured concrete topping. Note: Sleeves to have flat flanges and/or guides which rest on top of precast slab.	B	B

2.8 ESCUTCHEONS

A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.

B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome-plated finish.

C. One-Piece, Cast-Brass Type: With set screw.

1. Finish: Polished chrome-plated.

D. Split-Casting, Cast-Brass Type: With concealed hinge and set screw.

1. Finish: Polished chrome-plated.

E. One-Piece, Stamped-Steel Type: With set screw or spring clips and chrome-plated finish.

F. Split-Plate, Stamped-Steel Type: With exposed-rivet hinge, set screw or spring clips, and chrome-plated finish.

G. One-Piece, Floor-Plate Type: Cast-iron floor plate.

H. Split-Casting, Floor-Plate Type: Cast brass with concealed hinge and set screw.

2.9 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.

2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

3. Packaging: Premixed and factory packaged.

2.10 FIRESTOPPING

A. In addition to fire protection means specified elsewhere in this specification, this trade shall comply with the following.

B. All spaces between pipes and their respective sleeves shall be packed full depth with mineral wool, or other equally fire resistant material, and compressed firmly in place. Fiberglass shall not be used. Sleeve clearances shall not exceed ½ inch between pipes and sleeves. Use individual sleeves for each pipe or duct. Before escutcheons are attached caulking must be available for inspection and notification should be made.

C. Fire Stopping material and installed configuration shall maintain the fire rating of the penetrated wall, floor or ceiling.

D. All pipe penetrations requiring Fire Stopping shall be “UL” approved thru-wall fire stop assemblies.

E. Fire stop assemblies shall be Rectorseal, 3M, Hilti, Tremco or approved equal.

F. Contractor shall provided assembly for each type of pipe material thru fire-rated wall thickness.

G. Fire Stopping assemblies shall be approved by the authority having jurisdiction.

2.11 TOOLS AND LUBRICANTS

A. Furnish special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery furnished.

B. Lubricants: A minimum of one quart of oil, and one pound of grease, of equipment manufacturer's recommended grade and type, in unopened containers and properly identified as to use for each different application.

2.12 ACCESS DOORS IN FINISHED CONSTRUCTION

A. Access doors as required for operation and maintenance of concealed equipment, valves, controls, etc. will be provided by another trade.

1. This Trade is responsible for access door location, size and its accessibility to the valves or equipment being served.

2. Coordinate and prepare a location, size, and function schedule of access doors required and deliver to a representative of the installing trade.

3. Access doors shall be of ample size, minimum of 16" x 16".

2.13 FOUNDATIONS

A. General

1. All equipment, piping, etc., mounted on/or suspended from approved foundations and supports, as specified, as shown on the drawings.

2. All concrete foundations and supports (and required reinforcing and forms) will be provided by another trade. This trade shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although another trade will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade, which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, etc.

B. In seismic zones, provide lateral support for earthquake forces.

2.14 FOUNDATION

A. For all outdoor applications and all indoor applications in a harsh environment, refer to Section 09 09960 “High Performance Coatings.”

2.15 TOOLS AND LUBRICANTS

A. Furnish special tools not readily available commercially, that are required for disassembly or adjustment of equipment and machinery finished.

B. Lubricants: A minimum of one quart of oil, and one pound of grease, of equipment manufacturer’s recommended grade type, in unopened containers and properly

identified as to use for each different application.

PART 3 - EXECUTION

3.1 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 15 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:

1. New Piping:

(a) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.

(b) Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.

(c) Insulated Piping: One-piece, stamped-steel type with spring clips.

(d) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

(e) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

(f) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.

(g) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.

(h) Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated finish.

(i) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.

(j) Bare Piping in Equipment Rooms: One-piece, cast-brass type.

(k) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.

(l) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

M. Sleeves are not required for core-drilled holes.

N. Permanent sleeves are not required for holes formed by removable PE sleeves.

O. Install sleeves for pipes passing through poured concrete and masonry walls, gypsum-board partitions, and poured concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

(a) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches (50 mm) above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

3. Install sleeves that are large enough to provide 1/4-inch (6.4-mm) annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:

(a) Steel or Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).

(b) Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.

(c) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install

section of cast-iron soil pipe to extend sleeve to 2 inches (50 mm) above finished floor level. Refer to Division 7 Section "Sheet Metal Flashing and Trim" for flashing.

(1) Seal space outside of sleeve fittings with grout.

4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 7 Section #'s "Joint Sealants" for materials and installation.

P. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches (150 mm) in diameter.

2. Install cast-iron "wall pipes" for sleeves 6 inches (150 mm) and larger in diameter.

3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

Q. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

R. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 7 Section "Through-Penetration Firestop Systems" for materials.

S. Verify final equipment locations for roughing-in.

T. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

U. No installation shall be permitted which blocks or otherwise impedes access to any existing machine or system. Except as otherwise indicated, emergency switches and alarms shall be installed in conspicuous locations. All indicators, to include gauges, meters, and alarms shall be mounted in order to be easily visible by people in the area.

3.2 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 15 Sections specifying piping systems.

B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.

E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:

1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.

3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.

4. PVC Nonpressure Piping: Join according to ASTM D 2855.

K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 (DN 50) and smaller, adjacent to each valve and at final connection to each piece of equipment.

2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.

3. Dry Piping Systems: Install dielectric unions and flanges to connect piping materials of dissimilar metals.

4. Wet Piping Systems: Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals.

3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install mechanical equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

3.5 PAINTING

A. Painting of mechanical systems, equipment, and components is specified in Division 9 Section.

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

C. Provide prime coat painting for the following:

1. Miscellaneous steel and iron provided by the Plumbing Contractor.

2. Hangers and supports provided by the Plumbing Contractor.

3.6 CONCRETE BASES

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit.

2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.

3. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.

4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

5. Install anchor bolts to elevations required for proper attachment to supported equipment.

6. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 5 Section "Metal Fabrications" for structural steel.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor mechanical materials and equipment.

C. Field Welding: Comply with AWS D1.1.

3.8 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

A. Cut, fit, and place wood grounds, nailers, blocking, and anchorages to support, and anchor mechanical materials and equipment.

B. Select fastener sizes that will not penetrate members if opposite side will be exposed to view or will receive finish materials. Tighten connections between members. Install fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.9 GROUTING

A. Mix and install grout for mechanical equipment base bearing surfaces, pump and other equipment base plates, and anchors.

B. Clean surfaces that will come into contact with grout.

C. Provide forms as required for placement of grout.

D. Avoid air entrapment during placement of grout.

E. Place grout, completely filling equipment bases.

F. Place grout on concrete bases and provide smooth bearing surface for equipment.

G. Place grout around anchors.

H. Cure placed grout.

3.10 TESTS

A. Provide all designating signs for shutoff valves, control valves, alarms, and the like, as required by the agencies having jurisdiction.

B. Testing of Systems

1. Perform all required tests in the manner prescribed by and to the satisfaction of the local building department and local plumbing inspector, Owners Insurance Underwriters, and all authorities having jurisdiction. Owners and Architects representatives shall be present to inspect tests. Obtain all required certificates of approval and pay any fees or costs in conjunction therewith.

2. Provide and pay for all devices, materials, supplies, labor and power required in connection with all tests. All tests shall be made in the presence and to the satisfaction of the Architect and inspectors having jurisdiction.

3. Defects disclosed by the tests shall be repaired, or if required by the Architect, defective work shall be replaced with new work without extra charge to the Owner. Tests shall be repeated as directed, until all work is proven satisfactory.

4. This Contractor shall also be responsible for the work of other trades that may be damaged or disturbed by the tests, or the repair or replacement of his own work, and he shall, without extra charge to the Owner, restore to its original condition, work of the trades so damaged and disturbed, engaging the original Contractors to do the work of restoration.

3.11 INSTALLATION

A. Coordinate location of piping, sleeves, inserts, hangers and equipment. Locate piping, sleeves, inserts, hangers, and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.

3.12 PROTECTION AND CLEANING

A. Cleaning of Piping System (General)

1. During construction, properly cap, plug and cover all openings in pipe, lines and equipment nozzles so as to prevent the entrance of sand, dirt, and foreign matter. Each system of piping shall be flushed (for the purpose of

removing grit, dirt, sand, and foreign matter from the piping), for as long a time as is required to thoroughly clean the systems.

B. Adjusting (General)

1. After the entire installation has been completed, make all required adjustments to balancing valves, air vents, automatic controls, circulators, flush valves, faucets, pressure reducing valves, etc., until all performance requirements are met. All water circulating systems shall be properly balanced.

C. All bearings of all equipment shall be oiled or greased as recommended by the manufacturer, after installation.

D. The alignment of each centrifugal pump shall be checked and each pump shall be properly aligned after the pumps are placed in service. Mechanical seals and shaft sleeves shall be replaced by this Contractor without charge in the event that unusual wear or faulty operation occurs during the guarantee period.

E. Cleaning (General)

1. Upon completion of the work, all fixtures, trimmings and equipment shall be thoroughly cleaned, polished and left in first class condition for final acceptance.

3.13 EQUIPMENT PROVIDED UNDER OTHER SECTIONS OF THE WORK THAT REQUIRES PLUMBING

A. Certain equipment may be supplied under other sections of the work. This Contractor shall provide as described below the requirements and all necessary services roughing and final connections as shown on the plans and as required.

B. Installation of the equipment shall be performed in the following manner.

1. Roughing: Provide all water, waste and vent piping complete in accordance with detailed dimensioned drawings, to be provided by the equipment suppliers. This roughing shall be left ready for final connection to tables and equipment terminated at a point and height indicated by the Equipment Suppliers drawings.

2. Setting of Equipment: The Equipment Supplier will furnish and set in place and secure all equipment.

3. Final Connection: This trade shall make all final connections after the equipment has been set in place.

4. Trim: The Equipment Supplier will furnish all specialized appliances and trim such as faucets, tailpieces, strainers, service outlet bibbs, cocks, serrated hose connections and other related trim. This Trade shall coordinate and check with the Equipment Supplier and shall provide all valve, traps, stops, escutcheons, branch control valves, floor and funnel drains, nipples, fittings, tailpieces, pressure reducing valves, vacuum breakers, check valve, and other appurtenances which are not supplied by the Equipment Supplier and are necessary to the operating characteristics of the equipment being furnished. Also install all trim furnished with the equipment, as required, in accordance with the manufacturer's recommendations.

5. All exposed to view final connection piping, fittings, valves, etc., shall be chrome plated with finish matching equipment rim finishes. Submit finish samples to Architect for approval. Attention is hereby drawn to the Equipment Specifications being prepared under other sections of the work.

C. Review all Architectural drawings and equipment cuts for all equipment locations & services required at each piece of equipment.

3.14 EXCAVATION AND BACKFILL

A. Instructions:

1. Trenches shall be excavated so that pipe can be laid to the alignment and depth indicated on the drawings, and shall be excavated only so far in advance of pipe laying as approved.

2. Width of trenches shall be held to a minimum consistent with the type of material encountered and the size of the pipe being laid, but the width at the top of the pipe shall not be more than 2'-0" plus outside diameter of pipe. Excavation for manholes and other accessories shall have 12" minimum and a 24" maximum clearance on all sides.

3. Before fill or backfilling commences, all trash, debris and other foreign material shall be removed from trenches to be backfilled by this Trade. Fill material shall be free from timber, rocks 3" or larger, organic material, frozen material, and other unsuitable material as determined by the Architect. Filling shall not be done in freezing weather, unless specifically approved. No filling shall be done when material already in place is frozen.

4. In filling around pipe, deposit backfill material in successive horizontal layers not exceeding 6" in thickness before compaction. Compact each layer thoroughly by means of approved mechanical tampers. Take special care to obtain compaction under pipe haunches. Deposit backfill adjacent to pipes on both sides to approximately same elevation at the same time. Continue this method of filling and compacting until backfill is at least 18" above top of pipe.

5. Backfilling for the remainder of pipe trenches to subgrades of paved or landscaped areas shall be done by mechanical tamping and rolling equipment, except that the use of such equipment is prohibited when said use may result in damage to pipelines or structures.

6. Backfill shall be moistened as necessary for proper compaction. Water settling of fill will not be permitted.

7. Complete backfilling of pipe trenches as soon as possible after the pipe is laid and tested.

8. Existing pavements, roadways, walkways, curbs and landscaped areas disturbed during the progress of the excavation and backfill work shall be restored to their original condition at no additional cost to the Owner.

9. Backfill shall be compacted to a minimum of 90% of modified AASHO maximum density as defined by ASTM D-1557. Any layer of fill, or portion thereof, which is not compacted to the required density shall be recompacted until the specified density is achieved, or the layer shall be removed.

3.15 APPLIANCES, TOILET ROOM ACCESSORIES AND TRIM

A. Handle and install all Plumbing connected appliances claimed under Plumber's jurisdiction from tailboard delivery, including hoisting and rigging to designated locations.

B. Handle and install all accessories and trim claimed under Plumber's jurisdiction.

C. Dispose of all appliance and accessories packing crates and debris off of the site.

3.16 ARCHITECTURAL COORDINATION AND SAMPLES

A. All devices and appurtenances which are to be installed in all finished areas must be coordinated with the Architect for final approval as it relates to location, finish, materials, color, texture, etc.

B. Submit samples of all materials requested by the Architect.

C. Samples shall be prepared and submitted with all postage and transportation costs paid by the Contractor submitting same. Label each sample with identifying numbers and titles.

D. Submit samples of:

1. All exposed to view finishes such as cleanout plates, access covers, drain grates and tops, fixture trim, fresh air inlet plates, etc.

END OF SECTION 15051

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SECTION 15055 - MOTORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes basic requirements for factory-installed and field-installed motors.

B. Related Sections include the following:

1. Division 15 Section "Mechanical Vibration and Seismic Controls" for mounting motors and vibration isolation and seismic-control devices.

2. Division 15 Sections for application of motors and reference to specific motor requirements for motor-driven equipment.

1.3 DEFINITIONS

A. Factory-Installed Motor: A motor installed by motorized-equipment manufacturer as a component of equipment.

B. Field-Installed Motor: A motor installed at Project site and not factory installed as an integral component of motorized equipment.

1.4 SUBMITTALS

A. Product Data for Field-Installed Motors: For each type and size of motor, provide nameplate data and ratings; shipping, installed, and operating weights; mounting arrangements; size, type, and location of winding terminations; conduit entry and ground lug locations; and information on coatings or finishes.

B. Shop Drawings for Field-Installed Motors: Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:

1. Each installed unit's type and details.

2. Nameplate legends.

C. Manufacturer Seismic Qualification Certification: Submit certification that motors, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls." Include the following:

1. Test Reports: Written reports specified in Parts 2 and 3.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain field-installed motors of a single type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, as amended by state and local codes.

1.6 COORDINATION

A. Coordinate features of motors, installed units, and accessory devices. Provide motors that are:

1. Compatible with the following:

(a) Magnetic controllers.
(b) Multispeed controllers.
(c) Reduced-voltage controllers.

2. Designed and labeled for use with variable frequency controllers, and suitable for use throughout speed range without overheating.

3. Matched to torque and horsepower requirements of the load.

4. Matched to ratings and characteristics of supply circuit and required control sequence.

B. Coordinate motor support with requirements for driven load; access for maintenance and motor replacement; installation of accessories, belts, belt guards; and adjustment of sliding rails for belt tensioning.

C. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section.

PART 2 - PRODUCTS

2.1 MOTOR REQUIREMENTS

A. Motor requirements apply to factory-installed and field-installed motors except as follows:

1. Different ratings, performance, or characteristics for a motor are specified in another Section.

2. Manufacturer for a factory-installed motor requires ratings, performance, or characteristics, other than those specified in this Section, to meet performance specified.

2.2 MOTOR CHARACTERISTICS

A. Motors ½ HP and Larger: Three phase.

B. Motors Smaller Than ½ HP: Single phase.

C. Frequency Rating: 60 Hz.

D. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.

E. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.

F. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.

G. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

H. Enclosure: Open dripproof.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design E, medium induction motor. Efficiency in accordance with NEMA standards for Premium Efficient motors and with applicable EPACT Efficiency Standards.

B. Stator: Copper windings, unless otherwise indicated.

1. Multispeed motors shall have separate winding for each speed.

C. Rotor: Squirrel cage, unless otherwise indicated.

D. Bearings: Double-shielded, prelubricated ball bearings suitable for radial and thrust loading.

E. Temperature Rise: Match insulation rating, unless otherwise indicated.

F. Insulation: Class F, unless otherwise indicated.

G. Code Letter Designation:

1. Motors 15 HP and Larger: NEMA starting Code F or G.

2. Motors Smaller Than 15 HP: Manufacturer's standard starting characteristic.

H. Enclosure: Cast iron for motors 7.5 hp and larger; rolled steel for motors smaller than 7.5 hp.

1. Finish: Gray enamel.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Designed with critical vibration frequencies outside operating range of controller output.

2. Temperature Rise: Matched to rating for Class B insulation.

3. Insulation: Class H.

4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

5. Inverter rated: Comply with NEMA MG-1 Part 31.4.4.2 requirements for inverter rated motors.

C. Rugged-Duty Motors: Totally enclosed, with 1.25 minimum service factor, greased bearings, integral condensate drains, and capped relief vents. Windings insulated with nonhygroscopic material.

1. Finish: Chemical-resistant paint over corrosion-resistant primer.

2.5 SINGLE-PHASE MOTORS

A. Type: One of the following, to suit starting torque and requirements of specific motor application:

1. Permanent-split capacitor.

2. Split-phase start, capacitor run.

3. Capacitor start, capacitor run.

B. Shaded-Pole Motors: For motors 1/20 hp and smaller only.

C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

D. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, prelubricated-sleeve type for other single-phase motors.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas to receive field-installed motors for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of conduit systems to verify actual locations of conduit connections before motor installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 MOTOR INSTALLATION

A. Anchor each motor assembly to base, adjustable rails, or other support, arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and align with load transfer link.

B. Install motors on concrete bases complying with Division 3.

C. Comply with mounting and anchoring requirements specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

3.3 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Run each motor with its controller. Demonstrate correct rotation, alignment, and speed at motor design load.

2. Test interlocks and control features for proper operation.

3. Verify that current in each phase is within nameplate rating.

B. Testing: Perform the following field quality-control testing:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.15.1. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.4 ADJUSTING

A. Align motors, bases, shafts, pulleys and belts. Tension belts according to manufacturer's written instructions.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean motors, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 15055

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SECTION 15061 - PLUMBING - HANGERS, SUPPORTS, ANCHORS AND GUIDES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes hangers and supports for plumbing system piping and equipment.

B. Related Sections include the following:

1. Division 5 Section Metal Fabrications for materials for attaching hangers and supports to building structure.

2. Division 15 Section 15072 Plumbing - Vibration Controls and Seismic Restraints for vibration isolation and seismic restraint devices.

3. Division 15 Section 15140 Domestic water piping.

4. Division 15 Section 15150 Domestic water piping.

1.3 DEFINITIONS

A. MSS: Manufacturers Standardization Society for the Valve and Fittings Industry.

B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.4 PERFORMANCE REQUIREMENTS

A. Design channel support systems for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

B. Design heavy-duty steel trapezes for piping to support multiple pipes capable of supporting combined weight of supported systems, system contents, and test water.

C. Design seismic restraint hangers and supports for piping and equipment.

D. Design and obtain approval from authorities having jurisdiction for seismic restraint hangers and supports for piping and equipment.

1.5 SUBMITTALS

A. Product Data: For each type of pipe hanger, channel support system component, and thermal-hanger shield insert indicated.

B. Shop Drawings: Signed and sealed by a qualified professional engineer for multiple piping supports and trapeze hangers. Include design calculations and indicate size and characteristics of components and fabrication details.

C. Welding Certificates: Copies of certificates for welding procedures and operators.

1.6 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

B. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support and trapeze by a qualified professional engineer.

C. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for each multiple pipe support, trapeze, and seismic restraint by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of hangers and supports that are similar to those indicated for this Project in material, design, and extent.

PART 2- PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Pipe Hangers:

(a) B-Line Systems, Inc.

(b) Grinnell Corp.

(c) Michigan Hanger Co., Inc.

(d) PHD Manufacturing, Inc.

2. Channel Support Systems:

(a) B-Line Systems, Inc.

(b) Grinnell Corp.; Power-Strut Unit.

(c) Michigan Hanger Co., Inc.; O-Strut Div.

(d) Thomas & Betts Corp.

(e) Unistrut Corp.

3. Thermal-Hanger Shield Inserts:

(a) Carpenter & Patterson, Inc.

(b) Michigan Hanger Co., Inc.

(c) PHS Industries, Inc.

(d) Pipe Shields, Inc.

(e) Rilco Manufacturing Co., Inc.

4. Powder-Actuated Fastener Systems:

(a) Gunnebo Fastening Corp.

(b) Hilti, Inc.

(c) ITW Ramset/Red Head.

(d) Masterset Fastening Systems, Inc.

2.2 MANUFACTURED UNITS

A. Pipe Hangers, Supports, and Components: MSS SP-58, factory-fabricated components. Refer to "Hanger and Support Applications" Article in Part 3 for where to use specific hanger and support types.

1. Galvanized, Metallic Coatings: For piping and equipment that will not have field-applied finish.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

B. Channel Support Systems: MFMA-2, factory-fabricated components for field assembly.

1. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.

2. Nonmetallic Coatings: On attachments for electrolytic protection where attachments are in direct contact with copper tubing.

C. Thermal-Hanger Shield Inserts: 100-psi (690-kPa) minimum compressive-strength insulation, encased in sheet metal shield.

1. Material for Cold Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.

2. Material for Cold Piping: ASTM C 552, Type I cellular glass with vapor barrier.

3. Material for Cold Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate with vapor barrier.

4. Material for Hot Piping: ASTM C 552, Type I cellular glass or water-repellent-treated, ASTM C 533, Type I calcium silicate.

5. Material for Hot Piping: ASTM C 552, Type I cellular glass.

6. Material for Hot Piping: Water-repellent-treated, ASTM C 533, Type I calcium silicate.

7. For Trapeze or Clamped System: Insert and shield cover entire circumference of pipe.

8. For Clevis or Band Hanger: Insert and shield cover lower 180 degrees of pipe.

9. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.3 MISCELLANEOUS MATERIALS

A. Powder-Actuated Drive-Pin Fasteners: Powder-actuated-type, drive-pin attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

B. Mechanical-Anchor Fasteners: Insert-type attachments with pull-out and shear capacities appropriate for supported loads and building materials where used.

C. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars, black and galvanized.

D. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged, nonshrink and nonmetallic, dry, hydraulic-cement grout.

1. Characteristics: Post hardening and volume adjusting; recommended for both interior and exterior applications.

2. Properties: Nonstaining, noncorrosive, and nongaseous.

3. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3- EXECUTION

3.1 HANGER AND SUPPORT APPLICATIONS

A. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Specification Sections.

B. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Adjustable Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated stationary pipes, NPS ½ to NPS 30 (DN15 to DN750).

2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F (49 to 232 deg C) pipes, NPS 4 to NPS 16 (DN100 to DN400), requiring up to 4 inches (100 mm) of insulation.

3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN20 to DN600), requiring clamp flexibility and up to 4 inches (100 mm) of insulation.

4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS ½ to NPS 24 (DN15 to DN600), if little or no insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS ½ to NPS 4 (DN15 to DN100), to allow off-center closure for hanger installation before pipe erection.

6. Adjustable Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8 (DN20 to DN200).

7. Adjustable Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS ½ to NPS 8 (DN15 to DN200).

8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS ½ to NPS 8 (DN15 to DN200).

9. Adjustable Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS ½ to NPS 2 (DN15 to DN50).

10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8 (DN10 to DN200).

11. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3 (DN10 to DN80).

12. U-Bolts (MSS Type 24): For support of heavy pipe, NPS ½ to NPS 30 (DN15 to DN750).

13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.

14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange.

15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN100 to DN900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.

16. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN65 to DN900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN25 to DN750), from two rods if longitudinal movement caused by expansion and contraction might occur.

18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN65 to DN500), from single rod if horizontal movement caused by expansion and contraction might occur.

19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN50 to DN1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN50 to DN600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.

21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN50 to DN750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.

C. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500).

2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN20 to DN500), if longer ends are required for riser clamps.

D. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches (150 mm) for heavy loads.

2. Steel Clevises (MSS Type 14): For 120 to 450 deg F (49 to 232 deg C) piping installations.

3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.

4. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.

5. Steel Weldless Eye Nuts (MSS Type 17): For 120 to 450 deg F (49 to 232 deg C) piping installations.

E. Building Attachments: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.

4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.

5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.

6. C-Clamps (MSS Type 23): For structural shapes.

7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.

8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.

9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.

10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom

of steel I-beams for heavy loads, with link extensions.

11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.

12. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    (a) Light (MSS Type 31): 750 lb (340 kg).

    (b) Medium (MSS Type 32): 1500 lb (675 kg).

    (c) Heavy (MSS Type 33): 3000 lb (1350 kg).

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.

15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where head room is limited.

F. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.

2. Protection Shields (MSS Type 40): Of length recommended by manufacturer to prevent crushing insulation.

3. Thermal-Hanger Shield Inserts: For supporting insulated pipe, 360-degree insert of high-density, 100-psi (690-kPa) minimum compressive-strength, water-repellent-treated calcium silicate or cellular-glass pipe insulation, same thickness as adjoining insulation with vapor barrier and encased in 360-degree sheet metal shield.

G. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Specification Sections, install the following types:

1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.

2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).

3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.

4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.

5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.

6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

   (a) Horizontal (MSS Type 54): Mounted horizontally.

   (b) Vertical (MSS Type 55): Mounted vertically.

   (c) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.

3.2 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

1. Vertical Piping: MSS Type 8 or Type 42, clamps.

2. Individual, Straight, Horizontal Piping Runs: According to the following:

   (a) 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.

   (b) Longer Than 100 Feet (3 m): MSS Type 43, adjustable roller hangers.

   (c) Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.

4. Base of Vertical Piping: MSS Type 52, spring hangers.

B. Support vertical piping and tubing at base and at each floor.

C. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

D. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.

2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.

3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.

4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with ½-inch (13-mm) rod.

5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.

6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.

7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.

8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

E. Install supports for vertical steel piping every 15 feet (4.5 m).

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.

2. NPS 3 (DN 80): 60 inches (1500 mm) with ½-inch (13-mm) rod.

3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.

5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

6. NPS 15 (DN 375): 60 inches (1500 mm) with 1-inch (25-mm) rod.

7. Spacing for 10-foot (3-m) lengths may be increased to 10 feet (3 m). Spacing for fittings is limited to 60 inches (1500 mm).

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.

2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.

3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.

4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with ½-inch (13-mm) rod.

5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.

6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.

7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

I. Install supports for vertical copper tubing every 10 feet (3 m).

J. Install hangers for CPVC piping with the following maximum horizontal spacing and minimum rod dimeters:

1. NPS 1 (DN 25) and Smaller: 36 inches (900 mm) with 3/8-inch (10-mm) rod.

2. NPS 1-1/4 to NPS 2 (DN 32 to DN 50): 48 inches (1200 mm) with 3/8-inch (10-mm) rod.

3. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

4. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

5. NPS 6 (DN 150): 28 inches (1200 mm) with 3/4-inch (19-mm) rod.

6. NPS 8 (DN 200): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

K. Install supports for vertical CPVC piping every 60 inches (1500 mm) for NPS 1 (DN 25) and smaller and every 72 inches (1800 mm) for NPS 1-1/4 (DN 32) and larger.

L. Install hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2 (DN 50) and Smaller: 48 inches (1200 mm) with 3/8-inch (10-mm) rod.

2. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): 48 inches (1200 mm) with 1/2-inch (13-mm) rod.

3. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1200 mm) with 5/8-inch (16-mm) rod.

4. NPS 6 (DN 150): 48 inches (1200 mm) with 3/4-inch (19-mm) rod.

5. NPS 8 to NPS 12 (DN 200 to Dn 300): 48 inches (1200 mm) with 7/8-inch (22-mm) rod.

M. Install supports for vertical PVC piping every 48 inches (1200 mm).

N. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.3 HANGER AND SUPPORT INSTALLATION

A. Pipe Hanger and Support Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.

B. Channel Support System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled channel systems.

1. Field assemble and install according to manufacturer's written instructions.

C. Heavy-Duty Steel Trapeze Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated, heavy-duty trapezes.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D-1.1.

D. Install building attachments within concrete slabs or attach to structural steel. Space attachments within maximum piping span length indicated in MSS SP-69. Install additional attachments at concentrated loads, including valves, flanges, guides, strainers, and expansion joints, and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.

E. Install powder-actuated drive-pin fasteners in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.

F. Install mechanical-anchor fasteners in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

G. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.

H. Install hangers and supports to allow controlled thermal and seismic movement of

piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.

I. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

J. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9, "Building Services Piping," is not exceeded.

K. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

   (a) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

   (b) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.

   (c) Do not exceed pipe stress limits according to ASME B31.9.

2. Install MSS SP-58, Type 39 protection saddles, if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.

   (a) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.

3. Install MSS SP-58, Type 40 protective shields on cold piping with vapor barrier. Shields shall span arc of 180 degrees.

   (a) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN100) and larger if pipe is installed on rollers.

4. Shield Dimensions for Pipe: Not less than the following:

   (a) NPS 1/4 to NPS 3-1/2 (DN8 to DN90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.

   (b) NPS 4 (DN100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.

   (c) NPS 5 and NPS 6 (DN125 and DN150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.

   (d) NPS 8 to NPS 14 (DN200 to DN350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.

(e) NPS 16 to NPS 24 (DN400 to DN600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.

5. Pipes NPS 8 (DN200) and Larger: Include wood inserts.

6. Insert Material: Length at least as long as protective shield.

7. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.4 EQUIPMENT SUPPORTS

A. Fabricate structural-steel stands to suspend equipment from structure above or to support equipment above floor.

B. Grouting: Place grout under supports for equipment and make smooth bearing surface.

3.5 METAL FABRICATION

A. Cut, drill, and fit miscellaneous metal fabrications for heavy-duty steel trapezes and equipment supports.

B. Fit exposed connections together to form hairline joints. Field-weld connections that cannot be shop-welded because of shipping size limitations.

C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.

2. Obtain fusion without undercut or overlap.

3. Remove welding flux immediately.

4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.6 ADJUSTING

A. Hanger Adjustment: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.

3.7 PAINTING

A. Touching Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touching Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 9 Section "Painting."

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 15061

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section,

1.2 SUMMARY

A. This Section includes the following:

1. Elastomeric isolation pads and mounts.
2. Restrained eleastomeric isolation mounts.
3. Freestanding and restrained spring islolators.
4. Housed spring mounts.
5. Elastomeric hangers.
6. Spring hangers.
7. Spring hangers with vertical-limit stops.
8. Thrust limits.
9. Pipe riser resilient supports.
10. Resilient pipe guides.
11. Freestanding and restrained air spring isolators.
12. Seismic snubbers.
13. Restraining cables.
14. Steel and inertia, vibration isolation equipment bases.

1.3 DEFINITIONS

A. IBC: International Building Code.

1.4 PERFORMANCE REQUIREMENTS

A. A&E DG-SED edition.

1.5 QUALITY ASSURANCE

B. Welding: Qualify procedures and personnel according to AWS D1.1, “Structural Welding Code–Steel.”

1.6 SUBMITTALS

A. Product Data: Indicate types, styles, materials, and finishes for each type of isolator specified. Include load deflection curves.

B. Shop Drawings: Show designs and calculations, certified by a professional engineer, for the following:

2. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to the structure and to the supported equipment. Include auxiliary motor slides and rails, and base weights.

1.7 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section “Roof Accessories.”

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Seismic Snubber Units: Furnish replacement neoprene inserts for all snubbers.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a non-slip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: Standard neoprene.
2. Durometer Rating: 50.
3. Number of Layers: As indicated on Drawings.

B. Elastomeric Mounts: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Durometer Rating: 50.

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4"-thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 690 kPa.

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4"-thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

E. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.

2. Base: Factory drilled for bolting to structure.

3. Snubbers: Vertically adjustable to allow a maximum of 1/4" travel before contacting a resilient collar.

F. Elastomeric Hangers: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

G. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

H. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer “up-stop” on lower threaded rod.

I. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4" movement at start and stop.

J. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2"-thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 3.45 MPa and for equal resistance in all directions.

K. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of ½"-thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements..

2.3 VIBRATION ISOLATION EQUIPMENT BASES

A. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1" clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

B. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for field-applied, cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1" clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A36/A36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel angels on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.4 FACTORY FINISHES

A. Manufacturer’s standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be electrogalvanized. Hot-dip galvanized metal components for exterior use.

3. Baked enamel for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install thrust limits at centerline of thrust, symmetrical on either side of equipment..

D. Install steel angels or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

E. Install resilient bolt isolation washers on equipment anchor bolts.

3.3 EQUIPMENT BASES

A. Fill concrete inertia bases, after installing base frame, with 20.7-MPa concrete; trowel to a smooth finish.

1. Cast-in-place concrete materials and placement requirements are specified in Division 3.

B. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18" centers around the full perimeter of the base.

2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

6. Cast-in-place concrete materials and placement requirements are specified in Division 3.

3.4 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.

2. Isolator deflection.

3. Snubber minimum clearances.

3.5 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4" movement during start and stop.

D. Adjust active height of spring isolators.

E. Adjust snubbers according to manufacturer's written recommendations.

F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

G. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.6 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

END OF SECTION 15072

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SECTION 15075 - PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following mechanical identification materials and their installation:

1. Equipment nameplates.

2. Pipe markers.

3. Valve tags.

4. Valve schedules.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Valve numbering scheme.

D. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

A. Equipment Nameplates: Metal, with data engraved or stamped, for permanent attachment on equipment.

1. Data:

(a) Manufacturer, product name, model number, and serial number.

(b) Capacity, operating and power characteristics, and essential data.

(c) Labels of tested compliances.

2. Location: Accessible and visible.

3. Fasteners: As required to mount on equipment.

B. Equipment Markers: Engraved, color-coded laminated plastic. Include contact-type, permanent adhesive.

1. Terminology: Match schedules as closely as possible.

2. Data:

(a) Name and plan number.

(b) Equipment service.

(c) Design capacity.

(d) Other design parameters such as pressure drop, entering and leaving conditions, and speed.

3. Size: 2-1/2 by 4 inches (64 by 100 mm) for control devices, dampers, and valves; 4-1/2 by 6 inches (115 by 150 mm) for equipment.

C. Access Panel and Door Markers: 1/16-inch- (1.6-mm-) thick, engraved laminated plastic, with abbreviated terms and numbers corresponding to identification. Provide 1/8-inch (3.2-mm) center hole for attachment.

1. Fasteners: Self-tapping, stainless-steel screws or contact-type, permanent adhesive.

2.2 PIPING IDENTIFICATION DEVICES

A. Manufactured Pipe Markers, General: Preprinted, color-coded, with lettering indicating service, and showing direction of flow.

1. Colors: Comply with ASME A13.1, unless otherwise indicated.

2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length.

3. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Full-band pipe markers extending 360 degrees around pipe at each location.

4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Either full-band or strip-type pipe markers at least three times letter height and of length required for label.

5. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.

B. Pretensioned Pipe Markers: Precoiled semirigid plastic formed to cover full circumference of pipe and to attach to pipe without adhesive.

C. Shaped Pipe Markers: Preformed semirigid plastic formed to partially cover circumference of pipe and to attach to pipe with mechanical fasteners that do not penetrate insulation vapor barrier.

D. Self-Adhesive Pipe Markers: Plastic with pressure-sensitive, permanent-type, self-adhesive back.

E. Plastic Tape: Continuously printed, vinyl tape at least 3 mils (0.08 mm) thick with pressure-sensitive, permanent-type, self-adhesive back.

1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): 3/4 inch (19 mm) minimum.

2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches (150 mm) or Larger: 1-1/2 inches (38 mm) minimum.

2.3 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers. Provide 5/32-inch (4-mm) hole for fastener.

1. Material: 0.032-inch- (0.8-mm-) thick brass.

2. Valve-Tag Fasteners: Brass wire-link or S-hook.

2.4 VALVE SCHEDULES

A. Valve Schedules: For each piping system, on standard-size bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.

1. Valve-Schedule Frames: Glazed display frame for removable mounting on masonry walls for each page of valve schedule. Include mounting screws.

2. Frame: Extruded aluminum.

3. Glazing: ASTM C 1036, Type I, Class 1, Glazing Quality B, 2.5-mm, single-thickness glass.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

A. Products specified are for applications referenced in other Division 15 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

A. Install and permanently fasten equipment nameplates on each major item of mechanical equipment that does not have nameplate or has nameplate that is damaged or located where not easily visible. Locate nameplates where accessible and visible. Include nameplates for the following general categories of equipment:

1. Pumps, compressors and similar motor-driven units.

2. Water heaters, heat exchangers, etc.

B. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.

1. Letter Size: Minimum 1/4 inch (6.4 mm) for name of units if viewing distance is less than 24 inches (600 mm), ½ inch (13 mm) for viewing distances up to 72 inches (1830 mm), and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.

3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:

(a) Main control and operating valves, including safety devices and hazardous units such as gas outlets.

(b) Meters, gages, thermometers, and similar units.

(c) Fuel-burning units, including water heaters and heat exchangers.

(d) Pumps, compressors, and similar motor-driven units.

(e) Tanks and pressure vessels.

(f) Strainers, filters, water-treatment systems, and similar equipment.

C. Install access panel markers with screws on equipment access panels.

3.3 PIPING IDENTIFICATION

A. Install manufactured pipe markers indicating service on each piping system. Install with flow indication arrows showing direction of flow.

1. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Pretensioned pipe markers. Use size to ensure a tight fit.

2. Pipes with OD, Including Insulation, Less Than 6 Inches (150 mm): Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, [at least 3/4 inch (19 mm)] [1-1/2 inches (38 mm)] wide, lapped at least 1-1/2 inches (38 mm) at both ends of pipe marker, and covering full circumference of pipe.

3. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Shaped pipe markers. Use size to match pipe and secure with fasteners.

4. Pipes with OD, Including Insulation, 6 Inches (150 mm) and Larger: Self-adhesive pipe markers. Use color-coded, self-adhesive plastic tape, at least 1-1/2 inches (38 mm) wide, lapped at least 3 inches (75 mm) at both ends of pipe marker, and covering full circumference of pipe.

B. Locate pipe markers and color bands where piping is exposed in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior nonconcealed locations as follows:

1. Near each valve and control device.

2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.

3. Near penetrations through walls, floors, ceilings, and nonaccessible enclosures.

4. At access doors, manholes, and similar access points that permit view of concealed piping.

5. Near major equipment items and other points of origination and termination.

6. Spaced at maximum intervals of 50 feet (15 m) along each run. Reduce intervals to 25 feet (7.6 m) in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced markers.

3.4 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; plumbing fixture supply stops; shutoff valves; faucets; convenience and lawn-watering hose connections; and terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

TAGS SHOULD HAVE SYSTEM IDENTIFICATION STAMPED ON TAG

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following:

1. Valve-Tag Size and Shape:

(a) Cold Water: 1-1/2 inches (38 mm) or 2 inches (50 mm), round

(b) Hot Water: 1-1/2 inches (38 mm) or 2 inches (50 mm), round

(c) Gas: 1-1/2 inches (38 mm) or 2 inches (50 mm), round

2. Valve-Tag Color:

(a) Cold Water: Natural.

(b) Hot Water: Natural.

(c) Gas: Natural.

3. Letter Color:

(a) Cold Water: Black or White.

(b) Hot Water: Black or White.

(c) Gas: Black or White.

3.5 VALVE-SCHEDULE INSTALLATION

A. Mount valve schedule on wall in accessible location in each major equipment room.

3.6 ADJUSTING

A. Relocate mechanical identification materials and devices that have become visually blocked by other work

3.7 CLEANING

A. Clean faces of mechanical identification devices and glass frames of valve schedules.

END OF SECTION 15075

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SECTION 15083 - PIPE INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes preformed, rigid and flexible pipe insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

B. Related Sections include the following:

1. Division 7 Section "Firestopping" for firestopping materials and requirements for penetrations through fire and smoke barriers.

2. Division 15 Section "Hangers and Supports" for pipe insulation shields and protection saddles.

1.3 SUBMITTALS

A. Product Data: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.

B. Shop Drawings: Show fabrication and installation details for the following:

1. Application of protective shields, saddles, and inserts at pipe hangers for each type of insulation and hanger.

2. Attachment and covering of heat trace inside insulation.

3. Insulation application at pipe expansion joints for each type of insulation.

4. Insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

5. Removable insulation at piping specialties and equipment connections.

6. Application of field-applied jackets.

C. Samples: For each type of insulation and jacket. Identify each Sample, describing product and intended use. Submit Samples in the following sizes:

1. Preformed Pipe Insulation Materials: 12 inches (300 mm) long by NPS 2 (DN50).

2. Sheet Form Insulation Materials: 12 inches (300 mm) square.
3. Jacket Materials: 12 inches (300 mm) long by NPS 2 (DN50).

4. Manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.

D. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

E. Installer Certificates: Signed by the Contractor certifying that installers comply with requirements.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: As determined by testing materials identical to those specified in this Section according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and sealer and cement material containers with appropriate markings of applicable testing and inspecting agency.

1. Insulation Installed Indoors: Flame-spread rating of 25 or less, and smoke-developed rating of 50 or less.

2. Insulation Installed Outdoors: Flame-spread rating of 75 or less, and smoke-developed rating of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups according to the following requirements, using materials indicated for the completed Work:

1. Include the following mockups:

(a) One 10-foot (3-m) section of NPS 2 (DN50) straight pipe.

(b) One 90-degree elbow.

(c) One tee fitting.

(d) One NPS 2 (DN50) valve.

(e) Four support hangers, including hanger shield and insert.

(f) One strainer with removable portion of insulation.

(g) One reducer.

2. Build mockups with cutaway sections to allow observation of application details for insulation materials, mastics, attachments, and jackets.

3. Build mockups in the location indicated or, if not indicated, as directed by Architect.

4. Notify Architect seven days in advance of dates and times when mockups will be constructed.

5. Obtain Architect's approval of mockups before starting insulation application.

6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

7. Demolish and remove mockups when directed.

8. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Packaging: Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.

1.6 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 15 Section "Hangers and Supports."

B. Coordinate clearance requirements with piping Installer for insulation application.

C. Coordinate installation and testing of steam or electric heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after testing piping systems and, where required, after installing and testing heat-trace tape. Insulation application may begin on segments of piping that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Mineral-Fiber Insulation:

(a) CertainTeed Manson.

(b) Knauf FiberGlass GmbH.
(c) Owens-Corning Fiberglas Corp.

(d) Schuller International, Inc.

2. Cellular-Glass Insulation:

(a) Pittsburgh-Corning Corp.

3. Insulation:

(a) Armstrong World Industries, Inc.

(b) IMCOA.

4. Phenolic-Foam Insulation:

(a) Kooltherm Insulation Products, Ltd.

5. Calcium Silicate Insulation:

(a) Owens-Corning Fiberglas Corp.

(b) Pabco.

(c) Schuller International, Inc.

2.2 INSULATION MATERIALS

A. Type A - Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:

1. Preformed Pipe Insulation: Comply with ASTM C 547, Type 1, with factory-applied, all-purpose, vapor-retarder jacket.

2. Blanket Insulation: Comply with ASTM C 553, Type II, without facing.

3. Fire-Resistant Adhesive: Comply with MIL-A-3316C in the following classes and grades:

(a) Class 1, Grade A for bonding glass cloth and tape to unfaced glass-fiber insulation, for sealing edges of glass-fiber insulation, and for bonding lagging cloth to unfaced glass-fiber insulation.

(b) Class 2, Grade A for bonding glass-fiber insulation to metal surfaces.

4. Vapor-Retarder Mastics: Fire- and water-resistant, vapor-retarder mastic for indoor applications. Comply with MIL-C-19565C, Type II.

5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.

6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.

7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

B. Type B - Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.

1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class 1.

2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.

C. Closed-Cell Phenolic-Foam Insulation: Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.

D. Type C - Calcium Silicate Insulation: Preformed pipe sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Comply with ASTM C 533, Type I.

E. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.

2.3 INSULATION FOR PIPING AND EQUIPMENT

A. Piping and equipment shall be insulated in accordance with the following schedule: See paragraph 2.2 for Type

Service	Thickness and Type #	Notes
Domestic and non-potable hot water, hot water circulation mains, risers & branches.	1" Type 2.2-B Local branch piping to main, for ½" & 3/4" size maximum	
Exposed to freezing hot and cold, circulation domestic and non-potable mains, risers and branches.	1" Type 2.2-B 1" to 6" in size. 1½" Type 2.2-B 8" and larger in size	

Service	Thickness and Type #	Notes
Domestic, and non-potable cold water mains, risers, branches & pump discharge piping. All piping on factory packaged pumps.	½" Type 2.2-B	
Horizontal storm water piping and drain bodies interior and exterior	1" Type 2.2-B/ blanket may be used in non exposed areas only	Insulate all horizontal storm water piping & offsets from roof, deck, etc. drain to vertical leaders in cluding drain bodies. Insulate all storm water piping located above hung ceilings.
Water meter assembly	1" Type 2.2-A blanket	Insulate as required by local governing authority.
Chilled drinking water drainage piping from fixture to vertical stack. Fixture tailpiece, trap hot and cold riser.	1½" Type 2.2-B 2½" and larger in size As per authority having jurisdiction	
Sanitary exposed to freezing and traps w/ heat tracing	1" type 2.2C w/ .016" aluminum jacket	
Horizontal waste drain lines from floor or funnel drains in Mechanical Equipment Rooms to point of connection to vertical stack.	1" Type 2.2-A	
Piping provided with Electric Heating Cable as per manufacturer's recommendations.		

2.4 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type 1, unless otherwise indicated.

B. Foil and Paper Jacket: Laminated, glass-fiber-reinforced, flame-retardant kraft paper and aluminum foil.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils (0.5 mm) thick; roll stock ready for shop or field cutting and forming.

1. Adhesive: As recommended by insulation material manufacturer.

2. PVC Jacket Color: White or gray.

3. PVC Jacket Color: Color-code piping jackets based on materials contained within the piping system.

D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil- (0.75-mm-) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.

2. Adhesive: As recommended by insulation material manufacturer.

E. Standard PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 20-mil- (0.5-mm-) thick, high-impact, ultraviolet-resistant PVC.

1. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.

2. Adhesive: As recommended by insulation material manufacturer.

F. Aluminum Jacket: Factory cut and rolled to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

G. Aluminum Jacket: Aluminum roll stock, ready for shop or field cutting and forming to indicated sizes. Comply with ASTM B 209 (ASTM B 209M), 3003 alloy, H-14 temper.

1. Finish and Thickness: Smooth finish, 0.010 inch (0.25 mm) thick.

2. Finish and Thickness: Corrugated finish, 0.010 inch (0.25 mm) thick.

3. Finish and Thickness: Stucco-embossed finish, 0.016 inch (0.40 mm) thick.

4. Finish and Thickness: Painted finish, 0.016 inch (0.40 mm) thick.

5. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

6. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

H. Stainless-Steel Jacket: ASTM A 666, Type 304 or 316; 0.10 inch (2.5 mm) thick; and factory cut and rolled to indicated sizes.

I. Stainless-Steel Jacket: ASTM A 666, Type 304 or 316; 0.10 inch (2.5 mm) thick; and roll stock ready for shop or field cutting and forming to indicated sizes.

1. Moisture Barrier: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.

2. Moisture Barrier: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.

3. Elbows: Gore type, for 45- and 90-degree elbows in same material, finish, and thickness as jacket.

4. Jacket Bands: Stainless steel, Type 304, 3/4 inch (19 mm) wide.

2.5 ACCESSORIES AND ATTACHMENTS

A. Glass Cloth and Tape: Comply with MIL-C-20079H, Type I for cloth and Type II for tape. Woven glass-fiber fabrics, plain weave, presized a minimum of 8 oz./sq. yd. (270 g/sq. m).

1. Tape Width: 4 inches (100 mm).

B. Bands: 3/4 inch (19 mm) wide, in one of the following materials compatible with jacket:

1. Stainless Steel: ASTM A 666, Type 304; 0.020 inch (0.5 mm) thick.

2. Galvanized Steel: 0.005 inch (0.13 mm) thick.

3. Aluminum: 0.007 inch (0.18 mm) thick.

4. Brass: 0.010 inch (0.25 mm) thick.
5. Nickel-Copper Alloy: 0.005 inch (0.13 mm) thick.

C. Wire: 0.080-inch (2.0-mm), nickel-copper alloy; 0.062-inch (1.6-mm), soft-annealed, stainless steel; or 0.062-inch (1.6-mm), soft-annealed, galvanized steel.

2.6 VAPOR RETARDERS

A. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

2.7 WEATHERPROOFING FINISHES FOR OUTDOOR INSULATION

A. Outside Piping

1. Finish with a .016" thick aluminum jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturers recommendation.

2. Where field applied jacketing must be used, it shall be applied with 2" overlap facing down from the weather and shall be secured with an aluminum band (½" x .020") and seals applied on 12" center with bands applied directly over butt overlaps.

3. Fittings and valves shall be insulated and finished with mitered sections of the insulation with factory attached aluminum jackets installed per manufacturers recommendation.

2.8 PIPING INSULATION FOR ELECTRICALLY TRACED PIPING

A. Provide insulation of thickness shown for piping which is to be electrically traced. Note that insulation is provided by this trade over electric tracing provided by the electrical trade. Insulation types, see paragraph 2.3.

B. The following piping shall be specially insulated:

System	Area
Domestic Water	Outdoors or in unheated areas subject to freezing and other areas where indicated.
Sanitary Drainage Pipe and Traps	" "
Storm Water Drainage Piping	" "

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Preparation: Clean and dry pipe and fitting surfaces. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout the length of piping, including fittings, valves, and specialties.

B. Refer to schedules at the end of this Section for materials, forms, jackets, and thicknesses required for each piping system.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated. Refer to special instructions for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic.

1. Apply insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor retarders are indicated, extend insulation on anchor legs at least 12 inches (300 mm) from point of attachment to pipe and taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation application where vapor retarders are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

N. Apply adhesives and mastics at the manufacturer's recommended coverage rate.

O. Apply insulation with integral jackets as follows:

1. Pull jacket tight and smooth.

2. Circumferential Joints: Cover with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4 inches (100 mm) o.c.

3. Longitudinal Seams: Overlap jacket seams at least 1-1/2 inches (40 mm). Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches (100 mm) o.c.

(a) Exception: Do not staple longitudinal laps on insulation having a vapor retarder.

4. Vapor-Retarder Mastics: Where vapor retarders are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.

5. At penetrations in jackets for thermometers and pressure gages, fill and seal voids with vapor-retarder mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.

2. Apply insulation for exterior applications tightly joined to interior insulation ends.

3. Extend metal jacket of exterior insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal metal jacket to roof flashing with vapor-retarder mastic.

Q. Exterior Wall Penetrations: For penetrations of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retarder mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions.

1. Firestopping and fire-resistive joint sealers are specified in Division 7 Section "Firestopping."

T. Floor Penetrations: Apply insulation continuously through floor assembly.

1. For insulation with vapor retarders, seal insulation with vapor-retarder mastic where floor supports penetrate vapor retarder.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20 feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with standard PVC fitting covers.

4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

3. Apply insulation to flanges as specified for flange insulation application.

4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

6. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with standard PVC fitting covers.

4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

2. Apply insulation to flanges as specified for flange insulation application.

3. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.6 CLOSED-CELL PHENOLIC-FOAM INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with wire, tape, or bands without deforming insulation materials.

2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.

3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6 inches (150 mm) o.c.

4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.

4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered sections of phenolic-foam insulation. Secure insulation materials with wire, tape, or bands.

3. Cover fittings with standard PVC fitting covers.

4. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe

insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered segments of phenolic-foam insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

3. Apply insulation to flanges as specified for flange insulation application.

4. Use preformed standard PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

5. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

6. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.7 CALCIUM SILICATE INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with stainless-steel bands at 12-inch (300-mm) intervals and tighten without deforming insulation materials.

2. Apply two-layer insulation with joints tightly butted and staggered at least 3 inches (75 mm). Secure inner layer with 0.062-inch (1.6-mm), soft-annealed, stainless-steel wire spaced at 12-inch (300-mm) intervals. Secure outer layer with stainless-steel bands at 12-inch (300-mm) intervals.

3. Apply a skim coat of mineral-fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 1 inch (25 mm). Apply finish coat of lagging adhesive over glass cloth or tape. Thin the finish coat to achieve smooth finish.

B. Apply insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.

2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.

4. Finish flange insulation the same as pipe insulation.

C. Apply insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.

2. When premolded sections of insulation are not available, apply mitered sections of calcium silicate insulation. Secure insulation materials with stainless-steel wire.

3. Finish insulation of fittings the same as pipe insulation.

D. Apply insulation to valves and specialties as follows:

1. Apply mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to stainer basket without disturbing insulation.

2. Apply insulation to flanges as specified for flange insulation application.

3. Finish valve and specialty insulation the same as pipe insulation.

3.8 FIELD-APPLIED JACKET APPLICATION

A. Apply glass-cloth jacket, where indicated, directly over bare insulation or insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 2-inch (50-mm) overlap at seams and joints.

2. Embed glass cloth between two 0.062-inch- (1.6-mm-) thick coats of jacket manufacturer's recommended adhesive.

3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

B. Foil and Paper Jackets: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.

2. Apply lap or joint strips with the same material as jacket.

3. Secure jacket to insulation with manufacturer's recommended adhesive.

4. Apply jackets with 1-1/2-inch (40-mm) laps at longitudinal seams and 3-inch- (75-mm-) wide joint strips at end joints.

5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed

insulation with vapor-retarder mastic.

C. Apply PVC jacket where indicated, with 1-inch (25-mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

D. Apply metal jacket where indicated, with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.9 FINISHES

A. Glass-Cloth Jacketed Insulation: Paint insulation finished with glass-cloth jacket as specified in Division 9 Section "Painting."

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.10 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in schedules at the end of this Section.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.

2. Vibration-control devices.

3. Drainage piping located in crawl spaces, unless otherwise indicated.

4. Below-grade piping, unless otherwise indicated.

5. Chrome-plated pipes and fittings, unless potential for personnel injury.

6. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

3.11 FIELD QUALITY CONTROL

A. Inspection: Owner will engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

B. Inspection: Engage a qualified inspection agency to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

C. Inspection: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

1. Inspect fittings and valves randomly selected by Architect.

2. Remove fitting covers from 20 elbows or 1 percent of elbows, whichever is less, for various pipe sizes.

3. Remove fitting covers from 20 valves or 1 percent of valves, whichever is less, for various pipe sizes.

D. Insulation applications will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

E. Reinstall insulation and covers on fittings and valves uncovered for inspection according to these Specifications.

3.12 INSULATION APPLICATION SCHEDULE, GENERAL

A. Refer to insulation application schedules for required insulation materials, vapor retarders, and field-applied jackets.

B. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements.

3.13 INTERIOR INSULATION APPLICATION SCHEDULE

A. Service: Domestic hot and recirculated hot water.

1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: Foil and paper

5. Vapor Retarder Required: Yes.

6. Finish: None.

B. Service: Stormwater conductors.

1. Operating Temperature: 32 to 100 deg F (0 to 38 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3. Apply the following insulation

thicknesses:

4. Field-Applied Jacket: Foil and paper

5. Vapor Retarder Required: Yes.

6. Finish: None.

C. Service: Roof drain bodies.

1. Operating Temperature: 32 to 100 deg F (0 to 38 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: Foil and paper

5. Vapor Retarder Required: Yes.

6. Finish: None.

D. Service: Exposed sanitary drains and domestic water supplies and stops for fixtures for the disabled.

1. Operating Temperature: 35 to 120 deg F (2 to 49 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: PVC P-trap and supply covers.

5. Vapor Retarder Required: No.

6. Finish: Painted.

3.14 EXTERIOR INSULATION APPLICATION SCHEDULE

A. This application schedule is for aboveground insulation outside the building. Loose-fill insulation, for belowground piping, is specified in Division 2 piping distribution Sections.

B. Service: Domestic water.

1. Operating Temperature: 60 to 140 deg F (15 to 60 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket: Aluminum.

5. Vapor Retarder Required: Yes.

6. Finish: None.

C. Service: Storm water and sanitary drainage piping.

1. Operating Temperature: 32 to 100 deg F (0 to 38 deg C).

2. Insulation Material: See paragraph 2.3.

3. Insulation Thickness: See paragraph 2.3.

4. Field-Applied Jacket None.

5. Vapor Retarder Required: Yes

6. Finish: None.

END OF SECTION 15083

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15110 - PLUMBING VALVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. The valve schedule on the drawing indicates the particular valve desired at the various locations indicated. Corresponding valves as made by approved manufacturers may be submitted for approval.

B. This Section includes the following valves:

1. Copper-alloy ball valves.
2. Ferrous-alloy ball valves.
3. Ferrous-alloy butterfly valves.
4. High-pressure butterfly valves.
5. Bronze check valves.
6. Gray-iron swing check valves.
7. Bronze gate valves.
8. Cast-iron gate valves.
9. Cast-iron plug valves.
10. Resilient-seated, cast-iron, eccentric plug valves.
11. Chainwheel actuators.
12. Backflow preventors.
13. Water regulators.
14. Balancing valves.
15. Drain valves.
16. Strainers.

C. Related Sections include the following:

1. Division 2 piping Sections for general-duty and specialty valves for site construction piping.

2. Division 15, Section 15051 Basic Plumbing Materials, Methods and Requirements.

3. Division 15 Section 15075 Plumbing Identification for valve tags and charts.

1.3 DEFINITIONS

A. The following are standard abbreviations for valves:

1. CWP: Cold working pressure.

2. EPDM: Ethylene-propylene-diene terpolymer rubber.

3. NBR: Acrylonitrile-butadiene rubber.

4. PTFE: Polytetrafluoroethylene plastic.

5. SWP: Steam working pressure.

6. TFE: Tetrafluoroethylene plastic.

1.4 SUBMITTALS

A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:

1. Backflow preventers and water regulators.

2. Balancing valves.

1.5 QUALITY ASSURANCE

A. ASME Compliance: ASME B31.1 for power piping valves and ASME B31.9 for building services piping valves.

1. Exceptions: Domestic hot- and cold-water piping valves unless referenced.

B. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.

C. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:

1. Protect internal parts against rust and corrosion.

2. Protect threads, flange faces, grooves, and weld ends.

3. Set angle, gate, and globe valves closed to prevent rattling.

4. Set ball and plug valves open to minimize exposure of functional surfaces.

5. Set butterfly valves closed or slightly open.

6. Block check valves in either closed or open position.

B. Use the following precautions during storage:

1. Maintain valve end protection.

2. Store valves indoors and maintain at higher than ambient dew-point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include the manufacturers specified.

2.2 VALVES, GENERAL

A. Refer to Part 3 "Valve Applications" Article for applications of valves.

B. All valves shall have manufacturer name and pressure rating cast or stamped thereon. All valves shall be rated for system pressure they are used for.

C. Furnish one manufacturer’s guarantee for all valves.

D. Ball valves may be used on NPS 2 (DN 50) or less in size. Valves shall be two piece full-port brass and rated for 600 psi with maximum drop of 1 psi through valve.

E. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.

F. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.

G. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

H. Valve Actuators:

1. Chainwheel: For attachment to valves, of size and mounting height, as indicated in the "Valve Installation" Article in Part 3.

2. Gear Drive: For quarter-turn valves NPS 8 (DN 200) and larger.

3. Handwheel: For valves other than quarter-turn types.

4. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller, except plug valves.

5. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 10 plug valves, for each size square plug head.

I. Extended Valve Stems: On insulated valves.

J. Valve Flanges: ASME B16.1 for cast-iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.

K. Valve Grooved Ends: AWWA C606.

L. Solder Joint Ends: With sockets according to ASME B16.18.

1. Caution: Use solder with melting point below 840 deg F (454 deg C) for angle, check, gate, and globe valves; below 421 deg F (216 deg C) for ball valves.

M. Threaded Ends: With threads according to ASME B1.20.1.

N. Valve Bypass and Drain Connections: MSS SP-45.

O. Valve seals/packing shall not contain asbestos or other deleterious material. Valve packing for domestic water systems shall meet all AWWA requirements for potable water service.

2.3 BALL VALVES

A. Manufacturers:

1. Ball Valves:

(a) Conbraco Industries, Inc.; Apollo Div.

(b) Crane Co.; Crane Valve Group; Stockham Div.

(c) Grinnell Corporation.

(d) NIBCO INC.

(e) Watts Industries, Inc.; Water Products Div.

2.4 FERROUS-ALLOY BUTTERFLY VALVES

A. Manufacturers:

1. Flangeless Butterfly Valves:

(a) Bray International, Inc.

(b) Crane Co.; Crane Valve Group; Center Line.

(c) Crane Co.; Crane Valve Group; Stockham Div.

(d) Dover Corp.; Dover Resources Company; Norriseal Div.

(e) General Signal; DeZurik Unit.

(f) Grinnell Corporation.

(g) Hammond Valve.

(h) Milwaukee Valve Company.

(i) NIBCO INC.

(j) Watts Industries, Inc.; Water Products Div.

2. Single-Flange Butterfly Valves:

(a) Bray International, Inc.

(b) Crane Co.; Crane Valve Group; Center Line.

(c) Crane Co.; Crane Valve Group; Stockham Div.

(d) Dover Corp.; Dover Resources Company; Norriseal Div.

(e) General Signal; DeZurik Unit.

(f) Grinnell Corporation.

(g) Hammond Valve.

(h) Milwaukee Valve Company.

(i) NIBCO INC.

3. Flanged Butterfly Valves:

(a) Bray International, Inc.

(b) Grinnell Corporation.

(c) Mueller Steam Specialty.

4. Grooved-End, Ductile-Iron Butterfly Valves:

(a) Grinnell Corporation.

(b) McWane, Inc.; Kennedy Valve Div.

(c) Milwaukee Valve Company.

(d) NIBCO INC.

(e) Victaulic Co. of America.

2.5 HIGH-PRESSURE BUTTERFLY VALVES

A. Manufacturers:

1. Bray International, Inc.

2. General Signal; DeZurik Unit.

3. Grinnell Corporation.

4. Pratt, Henry Company.

5. Xomox Corporation.

B. High-Pressure Butterfly Valves, General: MSS SP-68.

C. Flangeless, Class 150, High-Pressure Butterfly Valves: Wafer type.

D. Single-Flange, Class 150, High-Pressure Butterfly Valves: Wafer type.

2.6 BRONZE CHECK VALVES

A. Manufacturers:

1. Bronze, Horizontal Lift Check Valves:

(a) Crane Co.; Crane Valve Group; Crane Valves.

(b) Crane Co.; Crane Valve Group; Stockham Div.

(c) Walworth Co.

2. Bronze, Swing Check Valves:

(a) Crane Co.; Crane Valve Group; Stockham Div.

(b) Grinnell Corporation.

(c) Hammond Valve.

(d) Milwaukee Valve Company.

(e) NIBCO INC.

(f) Watts Industries, Inc.; Water Products Div.

B. Bronze Check Valves, General: MSS SP-80.

2.7 GRAY-IRON SWING CHECK VALVES

A. Manufacturers:

1. Gray-Iron Swing Check Valves:

(a) Crane Co.; Crane Valve Group; Stockham Div.

(b) Grinnell Corporation.

(c) Hammond Valve.

(d) Milwaukee Valve Company.

(e) Mueller Co.

(f) NIBCO INC.

2. Grooved-End, Ductile-Iron Swing Check Valves:

(a) Grinnell Corporation.

(b) Mueller Co.

(c) Victaulic Co. of America.

B. Gray-Iron Swing Check Valves, General: MSS SP-71.

C. Type I, Class 125, gray-iron, swing check valves with metal seats.

D. Type II, Class 125, gray-iron, swing check valves with composition to metal seats.

E. 175-psig (1207-kPa) CWP Rating, Grooved-End, Swing Check Valves: Ductile-iron body with grooved or shouldered ends.

2.8 BRONZE GATE VALVES

A. All gate valves inside the building 4" and over shall be of the OS&Y type except where space conditions do not permit the installation of this type of valve.

B. Available Manufacturers:

1. Type 1, Bronze, Nonrising-Stem Gate Valves:

(a) Crane Co.; Crane Valve Group; Stockham Div.

(b) Grinnell Corporation.

(c) Hammond Valve.

(d) Milwaukee Valve Company.

(e) NIBCO INC.

(f) Watts Industries, Inc.; Water Products Div.

2. Type 2, Bronze, Rising-Stem, Solid-Wedge Gate Valves:

(a) Crane Co.; Crane Valve Group; Stockham Div.

(b) Grinnell Corporation.

(c) Hammond Valve.

(d) Milwaukee Valve Company.

(e) NIBCO INC.

3. Type 3, Bronze, Rising-Stem, Split-Wedge Gate Valves:

(a) Grinnell Corporation.

(b) NIBCO INC.

C. Bronze Gate Valves, General: MSS SP-80, with ferrous-alloy handwheel.

D. Type 1, Class 125, Bronze Gate Valves: Bronze body with nonrising stem and bronze solid wedge and union-ring bonnet.

E. Type 1, Class 150, Bronze Gate Valves: Bronze body with nonrising stem and bronze solid wedge and union-ring bonnet.

F. Type 2, Class 125, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

G. Type 2, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

H. Type 3, Class 125, Bronze Gate Valves: Bronze body with rising stem and bronze split wedge and union-ring bonnet.

I. Type 3, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze split wedge and union-ring bonnet.

2.9 CAST-IRON GATE VALVES

A. All gate valves inside the building 4" and over shall be of the OS&Y type except where space conditions do not permit the installation of this type of valve.

B. Manufacturers:

1. Type I, Cast-Iron, Nonrising-Stem Gate Valves:

   (a) Crane Co.; Crane Valve Group; Stockham Div.

   (b) Grinnell Corporation.

   (c) Hammond Valve.

   (d) Milwaukee Valve Company.

   (e) NIBCO INC.

   (f) Watts Industries, Inc.; Water Products Div.

2. Type I, Cast-Iron, Rising-Stem Gate Valves:

   (a) Crane Co.; Crane Valve Group; Stockham Div.

   (b) Grinnell Corporation.

   (c) Hammond Valve.

   (d) Milwaukee Valve Company.

   (e) NIBCO INC.

   (f) Watts Industries, Inc.; Water Products Div.

C. Cast-Iron Gate Valves, General: MSS SP-70, Type I.

D. Class 125, NRS, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, nonrising stem, and solid-wedge disc.

E. Class 125, OS&Y, Bronze-Mounted, Cast-Iron Gate Valves: Cast-iron body with bronze trim, rising stem, and solid-wedge disc.

F. Class 125, NRS, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, nonrising stem, and solid-wedge disc.

G. Class 125, OS&Y, All-Iron, Cast-Iron Gate Valves: Cast-iron body with cast-iron trim, rising stem, and solid-wedge disc.

2.10 CAST-IRON PLUG VALVES

A. Manufacturers:

1. Lubricated-Type, Cast-Iron Plug Valves:

(a) Milliken Valve Co., Inc.

(b) Nordstrom Valves, Inc.

(c) Olson Technologies; Homestead Div.

(d) Walworth Co.

2. Nonlubricated-Type, Cast-Iron Plug Valves:

(a) General Signal; DeZurik Unit.

(b) Grinnell Corporation.

(c) Mueller Flow Technologies.

(d) Xomox Corporation.

B. Cast-Iron Plug Valves, General: MSS SP-78.

C. Class 125 or 150, lubricated-type, cast-iron plug valves.

D. Class 125 or 150, nonlubricated-type, cast-iron plug valves.

2.11 RESILIENT-SEATED, CAST-IRON, ECCENTRIC PLUG VALVES

A. Available Manufacturers:

1. General Signal; DeZurik Unit.

2. Milliken Valve Company.

3. Olson Technologies; Homestead Div.

4. Pratt, Henry Company.

5. Val-Matic Valve & Mfg. Corp.

B. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 2-1/2 (DN 65) and Smaller: Design similar to MSS SP-108, and rated for 175-psig (1207-kPa) minimum CWP.

1. Resilient Seating Material: Suitable for potable-water service, unless otherwise indicated.

C. Resilient-Seated, Cast-Iron, Eccentric Plug Valves, NPS 3 (DN 80) and Larger: MSS SP-108, and rated for 175-psig (1207-kPa) minimum CWP.

1. Resilient Seating Material: Suitable for potable-water service, unless otherwise indicated.

2.12 CHAINWHEEL ACTUATORS

A. Available Manufacturers:

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries, Inc.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Sprocket Rim with Chain Guides: Ductile iron Cast iron Aluminum Bronze, of type and size required for valve. Include zinc coating.

2. Brackets: Type, number, size, and fasteners required to mount actuator on valve.

3. Chain: Hot-dip, galvanized steel Brass Stainless steel, of size required to fit sprocket rim.

2.13 BACKFLOW PREVENTERS

A. Approvals: Backflow preventors shall comply with the requirements of all applicable codes and standards in accordance with federal, state, city, and local authorities, including all certificates and approvals, as applicable.

B. Manufacturers:

1. Ames Co., Inc.

2. Cla-Val Co.

3. CMB Industries, Inc.; Febco Backflow Preventers.

4. Conbraco Industries, Inc.

5. Mueller Co.; Hersey Meters Div.

6. Watts Industries, Inc.; Water Products Div.

7. Zurn Industries, Inc.; Wilkins Div.

C. General: ASSE standard, backflow preventers.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

2. NPS 2-1/2 (DN 65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.

(a) Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Strainer: On inlet, if indicated.

D. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.

E. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.

F. Intermediate Atmospheric-Vent Backflow Preventers: ASSE 1012, suitable for continuous pressure application. Include inlet screen and two independent check valves with intermediate atmospheric vent.

G. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

H. Double-Check Backflow Prevention Assemblies: ASSE 1015, suitable for continuous pressure application. Include shutoff valves on inlet and outlet, and strainer on inlet; test cocks; and two positive-seating check valves.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

I. Antisiphon-Pressure-Type Vacuum Breakers: ASSE 1020, suitable for continuous pressure application. Include shutoff valves, spring-loaded check valve, spring-

loaded floating disc, test cocks, and atmospheric vent.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

J. Dual-Check-Valve-Type Backflow Preventers: ASSE 1024, suitable for continuous pressure application. Include union inlet and two independent check valves.

K. Dual-Check-Valve-Type Backflow Preventers: ASSE 1032, suitable for continuous pressure application for carbonated beverage dispensers. Include stainless-steel body; primary and secondary checks; ball check; intermediate atmospheric-vent port for relieving carbon dioxide; and threaded ends, NPS 3/8 (DN 10).

L. Laboratory Faucet Vacuum Breakers: ASSE 1035, suitable for continuous pressure application and chrome plated; consisting of primary and secondary checks; intermediate vacuum breaker; and threaded ends, NPS 1/4 or NPS 3/8 (DN 8 or DN 10) as required.

M. Reduced-Pressure Detector Assembly Backflow Preventers: ASSE 1047, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves; and bypass with displacement-type water meter, valves, and reduced-pressure backflow preventer.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

N. Double-Check Detector Assembly Backflow Preventers: ASSE 1048, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; two positive-seating check valves; and bypass with displacement-type water meter, valves, and double-check backflow preventer.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

O. Hose-Connection Backflow Preventers: ASSE 1052, suitable for at least 3-gpm (0.19-L/s) flow and applications with up to 10-foot head of water (30-kPa) back pressure. Include two check valves; intermediate atmospheric vent; and nonremovable, ASME B1.20.7, garden-hose threads on outlet.

P. Back-Siphonage Backflow Vacuum Breakers: ASSE 1056, suitable for continuous pressure and backflow applications. Include shutoff valves, check valve, test cocks, and vacuum vent.

2.14 WATER REGULATORS (PRESSURE REDUCING VALVES)

A. Manufacturers:

1. Cla-Val Co.

2. Watts Industries, Inc.; Water Products Div.

3. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE 1003, water regulators, rated for initial working pressure of 150 psig (1035 kPa) minimum. Include integral factory-installed or separate field-installed, Y-pattern strainer.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

(a) General-Duty Service: Single-seated, direct operated, unless otherwise indicated.

(b) Booster Heater Water Supply: Single-seated, direct operated with integral bypass.

2. NPS 2-1/2 (DN 65) and Larger: Bronze or cast-iron body with flanged ends. Include AWWA C550 or FDA-approved, interior epoxy coating for regulators with cast-iron body.

(a) Type: Single-seated, direct operated.

(b) Type: Pilot-operated, single- or double-seated, cast-iron-body main valve, with bronze-body pilot valve.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Standpipe Valves

a. See standpipe equipment under other sections of specifications.

2.15 BALANCING VALVES

A. Calibrated Balancing Valves: Adjustable, with two readout ports and memory setting indicator. Include manufacturer's standard hoses, fittings, valves, differential pressure meter, and carrying case.

1. Manufacturers:

(a) Amtrol, Inc.

(b) Armstrong Pumps, Inc.

(c) ITT Industries; Bell & Gossett Div.

(d) Taco, Inc.

(e) Tour & Andersson, Inc. (Victaulic)

(f) Watts Industries, Inc.; Water Products Div.

2. NPS 2 (DN 50) and Smaller: Bronze body with brass ball, adjustment knob, calibrated nameplate, and threaded or solder-joint ends.

3. NPS 2 (DN 50) and Smaller: Bronze, Y-pattern body with adjustment knob

and threaded ends.

4. NPS 2-1/2 (DN 65) and Larger: Cast-iron, Y-pattern body with bronze disc and flanged or grooved ends.

2.16 DRAIN VALVES

A. Install low points and base of all risers.

B. Hose-End Drain Valves: MSS SP-110, NPS 3/4 (DN 20) ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.

2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.

C. Hose-End Drain Valve: MSS SP-80, gate valve, Class 125, ASTM B 62 bronze body, with NPS 3/4 (DN 20) threaded or solder-joint inlet and ASME B1.20.7, garden-hose threads on outlet and cap. Hose bibbs are prohibited for this application.

D. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig (1380-kPa) minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 (DN 6) side drain outlet and cap.

2.17 STRAINERS

A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch (1.2-mm) round perforations, unless otherwise indicated.

1. Pressure Rating: 125-psig (860-kPa) minimum steam working pressure, unless otherwise indicated.

2. NPS 2 (DN 50) and Smaller: Bronze body, with female threaded ends.

3. NPS 2-1/2 (DN 65) and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.

4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.

(a) Drain: Hose-end drain valve.

5. T-Pattern Strainers: Malleable-iron or ductile-iron body with grooved ends; access end cap with drain plug and access coupling with rubber gasket.

6. Basket Strainers: Bolted flange or clamp cover, and basket with lift-out handle.

   (a) Type: Simplex with one basket

   (b) Drain: Hose-end drain valve.

B. Drainage Basket Strainers: Non-pressure-rated, cast-iron or coated-steel body; with bolted flange or clamp cover and drain with plug.

1. Basket: Bronze or stainless steel with 1/8- or 3/16-inch- (3.2- or 4.8-mm-) diameter holes and lift-out handle.

2. Female threaded ends for NPS 2 (DN 50) and smaller, and flanged ends for NPS 2-1/2 (DN 65) and larger.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

D. Examine threads on valve and mating pipe for form and cleanliness.

E. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

F. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE APPLICATIONS

A. Refer to valve schedule use the following:

1. Shutoff Service: Ball or gate valves.
2. Throttling Service: ball, butterfly, or.
3. Pump Discharge: Spring-loaded check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same

types of valves with higher SWP class or CWP ratings may be substituted.

C. Domestic Water Piping: Use the following types of valves:

1. Angle Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125 bronze.

2. Angle Valves, NPS 2-1/2 (DN 65) and Larger: Type II, Class 125, cast iron.

3. Ball Valves, NPS 2 (DN 50) and Smaller: Three-piece, 400-psig (2760-kPa) CWP rating, copper alloy.

4. Ball Valves, NPS 2-1/2 (DN 65) and Larger: Class 150 ferrous alloy.

5. Butterfly Valves, NPS 2-1/2 (DN 65) and Larger:Flanged, 150-psig CWP rating, ferrous alloy, with EPDM liner.

6. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 4, Class 125, bronze.

7. Swing Check Valves, NPS 2-1/2 (DN 65) and Larger: Type II, Class 125, gray iron.

8. Gate Valves, NPS 2 (DN 50) and Smaller: Type 1, Class 125 bronze.

9. Gate Valves, NPS 2-1/2 (DN 65) and Larger: Type I, Class 125, NRS, bronze-mounted cast iron.

10. Globe Valves, NPS 2 (DN 50) and Smaller: Type 2, Class 125, bronze.

11. Globe Valves, NPS 2-1/2 (DN 65) and Larger: Type I, Class 125, bronze-mounted cast iron.

12. Plug Valves, NPS 2 (DN 50) and Larger: Class 125 or 150, lubricated-type, cast iron.

13. Resilient-Seated, Eccentric Plug Valves, NPS 3 (DN 80) and Larger: 175-psig (1207-kPa) CWP rating, cast iron.

D. Select valves, except wafer and flangeless types, with the following end connections:

1. For Copper Tubing, NPS 2 (DN 50) and Smaller: Solder-joint or threaded ends, except provide valves with threaded ends for [condenser water,] heating hot water, steam, and steam condensate services.

2. For Copper Tubing, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged.

3. For Copper Tubing, NPS 5 (DN 125) and Larger: Flanged ends.

4. For Steel Piping, NPS 2 (DN 50) and Smaller: Threaded ends.

5. For Steel Piping, NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged ends.

6. For Steel Piping, NPS 5 (DN 125) and Larger: Flanged ends.

3.3 VALVE INSTALLATION

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

C. Locate valves for easy access and provide separate support where necessary.

D. Install valves in horizontal piping with stem at or above center of pipe.

E. Install valves in position to allow full stem movement.

F. Install chainwheel operators on valves NPS 4 (DN 100) and larger and more than 96 inches (2400 mm) above floor. Extend chains to 60 inches (1520 mm) above finished floor elevation.

G. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level.

H. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.

2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

3. Do not install bypass piping around backflow preventers.

4. Install backflow preventers between 18" and 60" above finished floor.

I. Install pressure regulators with inlet and outlet shutoff valves, inlet strainers and balance valve bypass. Install pressure gages on inlet and outlet.

J. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

3.4 JOINT CONSTRUCTION

A. Refer to Division 15 Section "Basic Plumbing Materials and Methods" for basic piping joint construction.

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

C. All welded joints for steel pipe shall be of the open V-butt type following approved welding procedures for metallic arc or oxy-acetylene carbon steel welded pipe joints. Pipe shall be millbeveled or machine beveled by this Trade. All scale and oxide must be removed with hammer, chisel or file, and the bevel left smooth and clean.

3.5 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

END OF SECTION 15110

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SECTION 15121 - PLUMBING
PIPE EXPANSION FITTINGS AND LOOPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes pipe expansion loops for mechanical piping systems, and the following:

1. Pipe bends and loops.

2. Guides and anchors.

1.3 PERFORMANCE REQUIREMENTS

A. Compatibility: Products suitable for piping system fluids, materials, working pressures, and temperatures.

B. Capability: Absorb 200 percent of maximum piping expansion between anchors.

1.4 SUBMITTALS

A. Product Date: For each type of expansion fitting indicated.

1.5 QUALITY ASSURANCE

A. Engineering Responsibility: Design and preparation of Shop Drawings and calculations for expansion fittings and loops by a qualified professional engineer.

1. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of expansion fitting and loops that are similar to those indicated for this Project in material, design, and extent.

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”

PART 2 - PRODUCTS

2.1 GUIDES

A. Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

2.2 MISCELLANEOUS MATERIALS

A. Structural Steel: ASTM A36/A36M.

B. Bolts and Nuts: ASME B18.10 or ASTM A183, steel, hex head.

C. Washers: ASTM F 844, steel, plain, flat washers.

D. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, and tension and shear capacities appropriate for application.

1. Stud: Threaded, zinc-coated carbon steel.

2. Expansion Plug: zinc-coated steel.

3. Washer and Nut: zinc-coated steel.

E. Chemical Fasteners: Insert-type stud bonding system and for use with hardened Portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.

2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.

3. Washer and Nut: zinc-coated steel.

F. Concrete: Portland cement mix, 20.7 MPa minimum. Refer to Division 3 Section “Cast-in-Place Concrete” for formwork, reinforcement, and concrete.

G. Grout: ASTM C 1107, Grade B, factory-mixed and -packaged non-shrink and nonmetallic grout; suitable for interior and exterior applications.

1. Characteristics: Post-hardening, volume-adjusting, dry, hydraulic-cement grout.

2. Properties: Non-staining, non-corrosive, and non-gaseous.

3. Design Mix: 34.5-MPa, 28-day compressive strength.

PART 3 - EXECUTION

3.1 PIPE BEND AND LOOP INSTALLATION

A. Install pipe bends and loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.

B. Attach pipe bends and loops to anchors.

1. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, “Welding and Brazing Qualifications.”

2. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer’s written instructions.

3.3 SWING CONNECTIONS

A. Connect risers and branch connections to mains with at least five pipe fittings, including tee in main.

3.4 GUIDE INSTALLATION

A. Expansion loops or flexible pipe connections shall be guided to confine the degree of pipe movement.

B. Attach guides to pipe and secure to building structure.

3.5 ANCHOR INSTALLATION

A. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.

B. Fabricate and install steel anchors by welding steel shapes, plates, and bars to piping and to structure. Comply with ASME B31.9 and AWS D1.1.

C. Construct concrete anchors of poured-in-place concrete of dimensions indicated and include embedded fasteners.

D. Install pipe anchors according to expansion fitting manufacturer’s written instructions if expansion fitting are indicated.

E. Use grout to form flat bearing surfaces for expansion fittings, guides, and anchors installed on or in concrete.

3.6 PAINTING

A. Touching Up - Clean field welds and abraded areas of shop paint. Pain exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide a minimum dry film thickness of 0.05 mm.

B. Galvanized Surfaces - Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 15121

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SECTION 15122 - PLUMBING
METERS AND GAGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following meters and gages for mechanical systems:

1. Thermometers.
2. Gages.
3. Test plugs.

B. Related Sections include the following:

1. Division 2 Section "Water Distribution" for domestic and fire-protection water service meters outside the building.
2. Division 2 Section "Natural Gas Distribution" for gas meters outside the building.
3. Division 15 Section "Plumbing - Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
4. Division 15 Section "Plumbing - Fuel Gas Piping" for gas meters inside the building.

1.3 DEFINITIONS

A. CR: Chlorosulfonated polyethylene synthetic rubber.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.4 SUBMITTALS

A. Product Data: Include scale range, ratings, and calibrated performance curves for each meter, gage, fitting, speciality, and accessory specified.

B. Shop Drawings: Include schedule indicating manufacturer’s number, scale range, fittings, and location for each meter and gage.

C. Product Certificates: Signed by manufacturers of meters and gages certifying accuracy under specified operating conditions and compliance with specified requirements.

D. Maintenance Data: For meters and gages to include in maintenance manuals specified in Division 1. Include data for the following:

1. Water meters.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Manufacturers:

1. Palmer - Wahl Instruments Inc.
2. Trerice, H. O. Co.
3. Weiss Instruments, Inc.
4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Die-cast aluminum or brass or chrome-plated brass, [**7 inches (178 mm)**] long.

C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.

D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.

E. Window: Glass.

F. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

G. Stem: Copper-plated steel, aluminum, or brass for thermowell installation and of length to suit installation.

H. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.3 DIRECT-MOUNTING, FILLED-SYSTEM DIAL THERMOMETERS

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. KOBOLD Instruments, Inc.
3. Marsh Bellofram.
4. Trerice, H. O. Co.
5. Weiss Instruments, Inc.

6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

B. Case: Liquid-filled type, drawn steel or cast aluminum or plastic, [**4-1/2-inch (114-mm)** diameter.

C. Element: Bourdon tube or other type of pressure element.

D. Movement: Mechanical, connecting element and pointer.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.

G. Window: Glass.

H. Ring: Metal.

I. Connector: Adjustable type, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device.

J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.4 BIMETALLIC DIAL THERMOMETERS

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Ernst Gage Co.
3. Eugene Ernst Products Co.
4. Marsh Bellofram.
5. Miljoco Corp.
6. NANMAC Corporation.
7. Noshok, Inc.
8. Palmer - Wahl Instruments Inc.
9. REO TEMP Instrument Corporation.
10. Tel-Tru Manufacturing Company.
11. Trerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

B. Description: Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.3.

C. Case: Dry or liquid-filled type, stainless steel with [**5-inch (127-mm)**] diameter.

D. Element: Bimetal coil.

E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.

F. Pointer: Red metal.

G. Window: Glass.

H. Ring: Stainless steel.

I. Connector: Adjustable angle type.

J. Stem: Metal, for thermowell installation and of length to suit installation.

K. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.5 THERMOWELLS

A. Manufacturers:

1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Ernst Gage Co.
4. Marsh Bellofram.
5. Miljoco Corp.
6. NANMAC Corporation.
7. Noshok, Inc.
8. Palmer - Wahl Instruments Inc.
9. REO TEMP Instrument Corporation.
10. Tel-Tru Manufacturing Company.
11. Trerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

B. Manufacturers: Same as manufacturer of thermometer being used.

C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

1. Material: Brass, for use in copper piping.

2. Material: Steel, for use in steel piping.

3. Extension-Neck Length: Nominal thickness of 50 mm, but not less than the thickness of insulation. Omit extension neck for sockets for piping not insulated.

4. Insertion Length: To extend to center of pipe.

5. Cap: Threaded, with chain permanently fastened to socket.

6. Heat-Transfer Fluid: Oil or graphite.

2.6 PRESSURE GAGES

A. Manufacturers:

1. AMETEK, Inc.; U.S. Gauge Div.
2. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
3. Ernst Gage Co.
4. Eugene Ernst Products Co.
5. KOBOLD Instruments, Inc.
6. Marsh Bellofram.
7. Miljoco Corp.
8. Noshok, Inc.
9. Palmer - Wahl Instruments Inc.
10. REO TEMP Instrument Corporation.
11. Trerice, H. O. Co.
12. Weiss Instruments, Inc.
13. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
14. WIKA Instrument Corporation.
15. Winters Instruments.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry or liquid-filled type, metal or plastic, [**6-inch (152-mm)**] diameter.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass or plastic.
8. Ring: Metal or plastic.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum-Pressure Range: 30-in. Hg of vacuum to 15 psig of pressure (100 kPa of vacuum to 103 kPa of pressure).
11. Range for Fluids under Pressure: Two times operating pressure.

C. Pressure-Gage Fittings:

1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
2. Syphons: NPS 1/4 (DN 8) coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.7 TEST PLUGS

A. Manufacturers:

1. Flow Design, Inc.
2. MG Piping Products Co.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Co.
6. Trerice, H. O. Co.
7. Watts Industries, Inc.; Water Products Div.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F (3450 kPa at 93 deg C).

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for air, water, oil, or gas service at 20 to 200 deg F (minus 7 to plus 93 deg C) shall be CR.
2. Insert material for air or water service at minus 30 to plus 275 deg F (minus 35 to plus 136 deg C) shall be EPDM.

E. Test Kit: Furnish one test kit(s) containing one pressure gage and adaptor, one thermometer(s), and carrying case. Pressure gage, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.

1. Pressure Gage: Small bourdon-tube insertion type with 2- to 3-inch- (51- to 76-mm-) diameter dial and probe. Dial range shall be 0 to 200 psig (0 to 1380 kPa).
2. Low-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 25 to 125 deg F (minus 4 to plus 52 deg C).
3. High-Range Thermometer: Small bimetallic insertion type with 1- to 2-inch- (25- to 51-mm-) diameter dial and tapered-end sensing element. Dial ranges shall be 0 to 220 deg F (minus 18 to plus 104 deg C).
4. Carrying case shall have formed instrument padding.

2.8 WATER METERS

A. Description: AWWA C703, UL-listed, water supplier-approved, main-line turbine, detector type; 1200-kPa working pressure; with strainer and with meter on bypass cubic meters as required by utility.

1. Bypass Meter: AWWA C701, turbine type, bronze.

PART 3 - EXECUTION

3.1 THERMOMETER APPLICATIONS

A.

Thermometer Location	Temperature Range
Hot water outlet of water heaters	30° to 240°F.
Cold water service into the building	0° to 100°F.
Cold water inlet to water heaters	0° to 100°F.
In hot water circulation line adjacent to and upstream of circulating pump	30° to 180°F.

B. Provide the following temperature ranges for thermometers:

1. Domestic Hot Water: 30 to 240 deg F, with 2-degree scale divisions (Minus 1 to plus 115 deg C, with 1-degree scale divisions).
2. Domestic Cold Water: 0 to 100 deg F, with 2-degree scale divisions (Minus 18 to plus 38 deg C, with 1-degree scale divisions).

3.2 GAGE APPLICATIONS

A. Gages

1. Provide pressure gages in accordance with the following schedule and as shown on the plans.

Gauge Location	Pressure Range
At each water service point of entry in building.	0-150 p.s.i.
Each pump suction	0-150 p.s.i.
Each pump discharge	0-250 p.s.i. or as required.
Cold supply and hot water supply for water heaters	0-150 p.s.i.
Cold water supply to mechanical make up.	0-150 p.s.i.
Inlet & outlet of master pressure reducing valves.	0-250 p.s.i. or as required.

3.3 INSTALLATIONS

A. Install direct-mounting thermometers and adjust vertical and tilted positions for ease of reading while standing on the floor.

B. Install thermowells with socket extending to center of pipe and in vertical position in piping tees where thermometers are indicated.

C. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.

D. Install needle-valve and snubber fitting in piping for each pressure gage for fluids (except steam).

E. Install test plugs in tees in piping.

3.4 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance for meters, gages, machines, and equipment.

B. Ground equipment according to Division 16 Section "Grounding and Bonding."

C. Connect wiring according to Division 16 Section "Conductors and Cables."

3.5 WATER METER INSTALLATION

A. Install water meters, piping, and specialties according to AWWA M6 and utility's requirements.

1. Install displacement-type water meters with shutoff valve on water meter inlet. Install valve on water meter outlet and valved bypass around meter, unless prohibited by authorities having jurisdiction.

2. Install compound-type water meters with shutoff valves on water meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.

3. Install detector-type water meters with shutoff valves on water meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.

3.6 ROUGHING-IN FOR WATER METERS

A. Install roughing-in piping and specialties for water meter installation according to utility's instructions and requirements.

3.7 ADJUSTING AND CLEANING

A. Calibrate meters according to manufacturer's written instructions, after installation.

B. Adjust faces of meters and gages to proper angle for best visibility.

C. Clean windows of meters and gages and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touch-up paint.

END OF SECTION 15122

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes domestic water piping and water meters inside the building.

B. Water meters shall be as required by the utility company furnished and installed by the Contractor.

C. Related Sections include the following:

1. Division 2 Section "Water Distribution" for water-service piping and water meters outside the building from source to the point where water-service piping enters the building.
2. Division 15 Section "Plumbing - Meters and Gages" for thermometers, pressure gages, and fittings.
3. Division 15 Section "Plumbing Specialties" for water distribution piping specialties.

1.3 DEFINITIONS

A. CPVC: Chlorinated polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing domestic water piping systems with 125 psig (860 kPa), unless otherwise indicated.

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings and water meters.

B. Water Samples: Specified in Part 3 "Cleaning" Article.

C. Field quality-control test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Pipe and Fitting Applications" Article for applications of pipe, tube, fitting, and joining materials.

B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A, Schedule 40, galvanized. Include ends matching joining method.

1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body, with ball-and-socket, metal-to-metal, bronze seating surface and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.4 COPPER TUBE AND FITTINGS

A. Hard Copper Tube: ASTM B 88, Types K and L (ASTM B 88M, Types A and B), water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought- copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
4. Copper, Grooved-End Fittings: ASTM B 75 (ASTM B 75M) copper tube or ASTM B 584 bronze castings.

2.5 VALVES

A. Bronze and cast-iron, general-duty valves are specified in Division 15 Section "Valves."

B. Balancing and drain valves are specified in Division 15 Section "Plumbing Specialties."

2.6 WATER METERS

A. Displacement-Type Water Meters NPS 2 (DN 50) and Smaller: AWWA C700, nutating-disc totalization meter with bronze case and 150-psig (1035-kPa) minimum working-pressure rating; with registration in gallons (liters) or cubic feet (cubic meters) as required by utility; and with threaded end connections.

1. Manufacturers:

   a. ABB.
   b. Badger Meter, Inc.
   c. Carlon Meter Company Inc.
   d. Invensys North American Water.
   e. Mueller Company.
   f. Schlumberger Limited; Water Div.
   g. Venture Measurement.

B. Turbine-Type Water Meters: AWWA C701, totalization meter with [150-psig (1035-kPa)] minimum working-pressure rating; with registration in gallons (liters) or cubic feet (cubic meters) as required by utility; and with the following end connections:

1. NPS 2 (DN 50) and Smaller: Threaded.
2. NPS 2-1/2 (DN 65) and Larger: Flanged.
3. Manufacturers:

   a. ABB.
   b. Badger Meter, Inc.
   c. Hays Fluid Controls.
   d. Invensys North American Water.
   e. Master Meter, Inc.
   f. McCrometer.
   g. Mueller Company.
   h. Schlumberger Limited; Water Div.
   i. SeaMetrics Inc.
   j. Venture Measurement.

C. Compound-Type Water Meters NPS 3 (DN 80) and Larger: AWWA C702, totalization meter with integral main-line and bypass meters, bronze case, and 150-psig (1035-kPa) minimum working-pressure rating; with registration in gallons (liters) or cubic feet (cubic meters) as required by utility; and with flanged end connections.

1. Manufacturers:

a. ABB.
b. Badger Meter, Inc.
c. Invensys North American Water.
d. Master Meter, Inc.
e. Mueller Company.
f. Schlumberger Limited; Water Div.

2. Proportional, Detector-Type Water Meters: With meter on bypass.

a. Bypass Meter: AWWA C701, turbine type with bronze case; size not less than one-half nominal size of main-line meter.

3. Turbine-Type Water Meters: With strainer and with meter on bypass.

a. Strainer: Full size, matching water meter.
b. Bypass Meter: AWWA C701, turbine type with bronze case; not less than NPS 2 (DN 50).

D. Remote Registration System: Direct-reading type complying with AWWA C706; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

E. Remote Registration System: Encoder-type complying with AWWA C707; modified with signal transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Excavating, trenching, and backfilling are specified in Division 2 Section "Earthwork."

3.2 PIPE AND FITTING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

C. Fitting Option: Extruded-tee connections and brazed joints may be used on aboveground copper tubing.

D. Under-Building-Slab, Water-Service Piping on Service Side of Water Meter: Refer to Division 2 Section "Water Distribution."

E. Domestic Water Piping on Service Side of Water Meter inside the Building: Use any of the following piping materials for each size range:

1. NPS 4 to NPS 12 (DN 100 to DN 300): Steel pipe; gray-iron, threaded fittings; and threaded joints.
2. NPS 4 to NPS 12 (DN 100 to DN 300): Steel pipe with grooved ends; steel-piping, grooved-end fittings; grooved-end-pipe couplings; and grooved joints.
3. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, [Type K (Type A)] [Type L (Type B)]; copper pressure fittings; and soldered joints.
4. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, [Type K (Type A)] [Type L (Type B)] with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.

F. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 4 (DN 100) and Smaller: [Soft] [Hard] copper tube, Type K (Type A); copper pressure fittings; and soldered joints.

G. Aboveground Domestic Water Piping: See schedule on the drawings:

3.3 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 (DN 50) and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
3. Hot-Water-Piping, Balancing Duty: Calibrated or Memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

B. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.

1. Install hose-end drain valves at low points in water mains, risers, and branches.
2. Install stop-and-waste drain valves where indicated.

D. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Calibrated balancing valves are specified in Division 15 Section "Plumbing Specialties."

3.4 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."

C. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall or floor. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Plumbing Materials and Methods."

D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 15 Section "Basic Plumbing Materials and Methods."

E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Pressure gages are specified in Division 15 Section "Plumbing - Meters and Gages," and drain valves and strainers are specified in Division 15 Section "Plumbing Specialties."

F. Install water-pressure regulators downstream from shutoff valves. Water-pressure regulators are specified in Division 15 Section "Plumbing Specialties."

G. Install domestic water piping level and plumb.

H. Rough-in domestic water piping for water-meter installation according to utility company's requirements.

3.5 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Plumbing Materials and Methods."

B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

C. Extruded-Tee Connections: Form tee in copper tube according to ASTM F 2014. Use tool designed for copper tube; drill pilot hole, form collar for outlet, dimple tube to form seating stop, and braze branch tube into collar.

3.6 WATER METER INSTALLATION

A. Rough-in domestic water piping and install water meters according to utility company's requirements.

B. Coordinate water meter installation with utility company.

C. Install water meters according to AWWA M6 and utility's requirements.

1. Install displacement-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
2. Install turbine-type water meters with shutoff valve on water-meter inlet. Install valve on water-meter outlet and valved bypass around meter unless prohibited by authorities having jurisdiction.
3. Install compound-type water meters with shutoff valves on water-meter inlet and outlet and on valved bypass around meter. Support meters, valves, and piping on brick or concrete piers.
4. Install fire-service water meters with shutoff valves on water-meter inlet and outlet and on full-size valved bypass around meter. Support meter, valves, and piping on brick or concrete piers.
5. Install remote registration system according to standards of utility and of authorities having jurisdiction.

3.7 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 15 Section "Plumbing - Vibration and Seismic Controls."

B. Pipe hanger and support devices are specified in Division 15 Section "Plumbing - Hangers and Supports." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Individual, Straight, Horizontal Piping Runs: According to the following:

   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m): MSS Type 49, spring cushion rolls, if indicated.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, to a minimum of 3/8 inch (10 mm).

F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32) and Smaller: 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.
7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

G. Install supports for vertical steel piping every 15 feet (4.5 m).

H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 3/4 (DN 20) and Smaller: 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
6. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
7. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

I. Install supports for vertical copper tubing every 10 feet (3 m).

J. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.8 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment and machines to allow service and maintenance.

C. Connect domestic water piping to exterior water-service piping. Use transition fitting to join dissimilar piping materials.

D. Connect domestic water piping to water-service piping with shutoff valve, and extend and connect to the following:

1. Booster Pumps: Cold-water suction and discharge piping.
2. Water Heaters: Cold-water supply and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 15 Section "Plumbing Fixtures."

4. Equipment: Cold- and hot-water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.9 FIELD QUALITY CONTROL

A. Inspect domestic water piping as follows:

1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:

   a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
   b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

3. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.
4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

B. Test domestic water piping as follows:

1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
4. Cap and subject piping to static water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.10 ADJUSTING

A. Perform the following adjustments before operation:

1. Close drain valves, hydrants, and hose bibbs.
2. Open shutoff valves to fully open position.
3. Open throttling valves to proper setting.
4. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow.

a. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch.
b. Adjust calibrated balancing valves to flows indicated.

5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.11 CLEANING

A. Clean and disinfect potable and/or non-potable domestic water piping as follows:

1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:

a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
b. Fill and isolate system according to either of the following:

1) Fill system or part thereof with water/chlorine solution with at least 50 ppm (50 mg/L) of chlorine. Isolate with valves and allow to stand for 24 hours.
2) Fill system or part thereof with water/chlorine solution with at least 200 ppm (200 mg/L) of chlorine. Isolate and allow to stand for three hours.

c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.

B. Prepare and submit reports of purging and disinfecting activities.

C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 15140

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for soil, waste, and vent piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.
3. Encasement for underground metal piping.

B. Related Sections include the following:

1. Division 15 Section "Plumbing - Chemical-Waste Piping" for chemical-waste and vent piping systems.
2. Division 15 Section "Plumbing - Sewage Pumps."

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. EPDM: Ethylene-propylene-diene terpolymer rubber.

C. LLDPE: Linear, low-density polyethylene plastic.

D. NBR: Acrylonitrile-butadiene rubber.

E. PE: Polyethylene plastic.

F. PVC: Polyvinyl chloride plastic.

G. TPE: Thermoplastic elastomer.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:

1. Sanitary, Vent and Storm Drainage Piping: 10-foot head of water (30 kPa)..
2. Sanitary Sewer, Force-Main Piping: 50 psig (345 kPa).

B. Seismic Performance: Sanitary, vent and storm drainage piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.5 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Shop Drawings:

1. Design Calculations: Signed and sealed by a qualified professional engineer for selecting seismic restraints.

C. Field quality-control inspection and test reports.

1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency..

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
2. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 HUB-AND-SPIGOT, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 74, Service class.

B. Gaskets: ASTM C 564, rubber.

C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.4 HUBLESS CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.

1. Heavy-Duty, Shielded, Stainless-Steel Couplings: With stainless-steel shield, stainless-steel bands and tightening devices, and ASTM C 564, rubber sleeve.

a. Manufacturers:

1) ANACO.
2) Clamp-All Corp.
3) Ideal Div.; Stant Corp.
4) Mission Rubber Co.
5) Tyler Pipe; Soil Pipe Div.

2. Heavy-Duty, Shielded, Cast-Iron Couplings: ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve.

a. Manufacturer:

1) MG Piping Products Co..

2.5 GALVANIZED STEEL PIPE AND FITTINGS

A. Galvanized Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Schedule 40, galvanized. Include ends matching joining method.

B. Drainage Fittings: ASME B16.12, galvanized, threaded, cast-iron drainage pattern.

C. Pressure Fittings:

1. Galvanized Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
3. Gray-Iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast-Iron Flanges: ASME B16.1, Class 125.
5. Cast-Iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

2.6 DUCTILE-IRON PIPE AND FITTINGS

A. Mechanical-Joint, Ductile-Iron Pipe: AWWA C151, with mechanical-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.

B. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.

1. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
2. Gaskets: AWWA C111, rubber.

C. Flanges: ASME 16.1, Class 125, cast iron.

2.7 COPPER TUBE AND FITTINGS

A. Copper Type M (Type C) Tube: ASTM B 306, drainage tube, drawn temper.

1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

B. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.8 SPECIAL PIPE FITTINGS

A. Flexible, Nonpressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

a. Dallas Specialty & Mfg. Co.
b. Fernco, Inc.
c. Logan Clay Products Company (The).
d. Mission Rubber Co.
e. NDS, Inc.
f. Plastic Oddities, Inc.

2. Sleeve Materials:

   a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
   b. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.

B. Shielded Nonpressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturers:

   a. Cascade Waterworks Mfg. Co.
   b. Mission Rubber Co.

C. Rigid, Unshielded, Nonpressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.

1. Manufacturer:

   a. ANACO.

D. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.

1. Manufacturers:

   a. Cascade Waterworks Mfg. Co.
   b. Dresser, Inc.; DMD Div.
   c. EBAA Iron Sales, Inc.
   d. Ford Meter Box Company, Inc. (The); Pipe Products Div.
   e. JCM Industries, Inc.
   f. Romac Industries, Inc.
   g. Smith-Blair, Inc.
   h. Viking Johnson.

2. Center-Sleeve Material: Manufacturer's standard
3. Gasket Material: Natural or synthetic rubber.
4. Metal Component Finish: Corrosion-resistant coating or material.

E. Wall-Penetration Fittings: Compound, ductile-iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile-iron glands, rubber gaskets, and steel bolts.

1. Manufacturer:

   a. SIGMA Corp.

2.9 ENCASEMENT FOR UNDERGROUND METAL PIPING (EDIT)

A. Description: ASTM A 674 or AWWA C105, high-density, crosslaminated PE film of 0.004-inch (0.10-mm) minimum thickness.

B. Form: tube.

C. Color Black.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 2 Section "Earthwork" for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.

B. Aboveground, sanitary, vent and storm drainage piping NPS 2 (DN 50) and larger shall be the following:

1. Service class, cast-iron soil pipe and fittings; gaskets; and gasketed joints.
2. Hubless cast-iron soil pipe and fittings heavy-duty shielded, stainless-steel couplings; and hubless-coupling joints.
3. Steel pipe, drainage fittings, and threaded joints.
4. Copper DWV tube, copper drainage fittings, and soldered joints.
5. Dissimilar Pipe-Material Couplings: Shielded, nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

C. Underground, sanitary, vent and storm drainage piping NPS 2 (DN 50) and larger shall be the following:

1. Service class, cast-iron soil piping; gaskets; and gasketed joints.

2. Dissimilar Pipe-Material Couplings: Shielded nonpressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

D. Aboveground sanitary-sewage force mains [NPS 1-1/2 and NPS 6 (DN 40 and DN 150)] shall be any of the following:

1. Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

2. Galvanized steel pipe, pressure fittings, and threaded joints.

3.3 PIPING INSTALLATION

A. Sanitary sewer piping outside the building is specified in Division 2 Section "Sanitary Sewerage."

B. Basic piping installation requirements are specified in Division 15 Section "Basic Plumbing Materials and Methods."

C. Install seismic restraints on piping. Seismic-restraint devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

D. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.

E. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.

F. Install underground, ductile-iron, special pipe fittings according to AWWA C600.

1. Install encasement on piping according to ASTM A 674 or AWWA C105.

G. Install cast-iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 15 Section "Basic Mechanical Materials and Methods."

H. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.

I. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."

1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.

J. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.

K. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.

L. Install sanitary, vent and storm drainage piping at the following minimum slopes, unless otherwise indicated:

1. Building Sanitary and Storm Drain: 2 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
2. Horizontal Sanitary and Storm Drainage Piping: 2 percent downward in direction of flow.
3. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.

M. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.

N. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

O. Vent piping shall be run in a system of branches and stacks continuously upward to a point of minimum 24" (1800 mm) above the roof.

3.4 JOINT CONSTRUCTION

A. Basic piping joint construction requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Join hub-and-spigot, cast-iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.

C. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.

D. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.

E. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

F. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.5 VALVE INSTALLATION

A. General valve installation requirements are specified in Division 15 Section "Valves."

B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.

1. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.

C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

A. Seismic-restraint devices are specified in Division 15 Section "Plumbing - Vibration Controls and Seismic Restraints."

B. Pipe hangers and supports are specified in Division 15 Section "Plumbing - Hangers and Supports." Install the following:

1. Vertical Piping: MSS Type 8 or Type 42, clamps.
2. Install individual, straight, horizontal piping runs according to the following:

   a. 100 Feet (30 m) and Less: MSS Type 1, adjustable, steel clevis hangers.
   b. Longer Than 100 Feet (30 m): MSS Type 43, adjustable roller hangers.
   c. Longer Than 100 Feet (30 m), if Indicated: MSS Type 49, spring cushion rolls.

3. Multiple, Straight, Horizontal Piping Runs 100 Feet (30 m) or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
4. Base of Vertical Piping: MSS Type 52, spring hangers.

C. Install supports according to Division 15 Section "Plumbing - Hangers and Supports."

D. Support vertical piping and tubing at base and at each floor.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch (10-mm) minimum rods.

F. Install hangers for cast-iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1500 mm) with 3/8-inch (10-mm) rod.
2. NPS 3 (DN 80): 60 inches (1500 mm) with 1/2-inch (13-mm) rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1500 mm) with 5/8-inch (16-mm) rod.
4. NPS 6 (DN 150): 60 inches (1500 mm) with 3/4-inch (19-mm) rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1500 mm) with 7/8-inch (22-mm) rod.

G. Install supports for vertical cast-iron soil piping every 15 feet (4.5 m).

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 84 inches (2100 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 (DN 40): 108 inches (2700 mm) with 3/8-inch (10-mm) rod.
3. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
4. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
5. NPS 3 (DN 80): 12 feet (3.7 m) with 1/2-inch (13-mm) rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.7 m) with 5/8-inch (16-mm) rod.

7. NPS 6 (DN 150): 12 feet (3.7 m) with 3/4-inch (19-mm) rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.7 m) with 7/8-inch (22-mm) rod.

I. Install supports for vertical steel piping every 15 feet (4.5 m).

J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 72 inches (1800 mm) with 3/8-inch (10-mm) rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2400 mm) with 3/8-inch (10-mm) rod.
3. NPS 2-1/2 (DN 65): 108 inches (2700 mm) with 1/2-inch (13-mm) rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet (3 m) with 1/2-inch (13-mm) rod.
5. NPS 6 (DN 150): 10 feet (3 m) with 5/8-inch (16-mm) rod.
6. NPS 8 (DN 200): 10 feet (3 m) with 3/4-inch (19-mm) rod.

K. Install supports for vertical copper tubing every 10 feet (3 m).

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.7 CONNECTIONS

A. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.

C. Connect drainage and vent piping to the following:

1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

D. Connect force-main piping to the following:

1. Waste Pumps: To sewage pump discharge.

3.8 FIELD QUALITY CONTROL

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.

2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary, storm drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water (30 kPa). From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg (250 Pa). Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.

5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.

6. Prepare reports for tests and required corrective action.

E. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.

2. Cap and subject piping to static-water pressure of 50 psig (345 kPa) above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.

3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
4. Prepare reports for tests and required corrective action.

3.9 CLEANING

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops

END OF SECTION 15150

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes fuel gas piping within the building. Products include the following:

1. Pipe, tube, fittings, and joining materials.
2. Protective pipe and fitting coating.
3. Piping specialties.
4. Specialty valves.
5. Service meters.
6. Pressure regulators.

B. Related Sections include the following:

1. Division 2 Section "Natural Gas Distribution" for natural gas service piping, specialties, and accessories outside the building.
2. Division 2 Section "Liquid Petroleum Gas Distribution."

1.3 PROJECT CONDITIONS

A. Gas System Pressure: One pressure range. **0.5 psig (3.45 kPa)** or less.

B. Design values of fuel gas supplied for these systems are as follows:

1. Nominal Heating Value (Natural Gas): **1000 Btu/cu. ft. (37.3 MJ/cu. m)**.
2. Nominal Specific Gravity: 0.6.

1.4 SUBMITTALS

A. Product Data: For the following:

1. Corrugated, stainless-steel tubing systems. Include associated components.
2. Specialty valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
3. Service-meter bars. Include service-meter size of selected models.
4. Service meters. Include pressure rating and capacity of selected models.
5. Service-meter bypass fittings.
6. Pressure regulators. Include pressure rating, capacity, and settings of selected models.

B. Shop Drawings: For fuel gas piping. Include plans and attachments to other work.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Welding certificates.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For natural gas specialties and accessories to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

B. Electrical Components and Devices: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. NFPA Standard: Comply with NFPA 54, "National Fuel Gas Code."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Handling Flammable Liquids: Remove and legally dispose of liquids from drips in existing gas piping. Handle cautiously to avoid spillage and ignition. Notify fuel gas supplier. Handle flammable liquids used by Installer with proper precautions and do not leave on premises from end of one day to beginning of next day.

1.7 COORDINATION

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without Architect's written permission.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 PIPING MATERIALS

A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.

2.3 CORRUGATED, STAINLESS-STEEL TUBING SYSTEMS

A. Description: Comply with AGA LC 1 and include the following:

1. Tubing: Corrugated stainless steel with plastic jacket or coating.
2. Fittings: Copper alloy with ends made to fit corrugated tubing. Include ends with threads according to ASME B1.20.1 if connection to threaded pipe or fittings is required.
3. Striker Plates: Steel, designed to protect tubing from penetrations.
4. Manifolds: Malleable iron or steel with protective coating. Include threaded connections according to ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
5. Manufacturers:
   a. OmegaFlex, Inc.
   b. Titeflex Corp.
   c. Tru-Flex Metal Hose Corp.
   d. Ward Industries, Inc.

2.4 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

A. Steel Pipe: ASTM A 53/A 53M; Type E or S; Grade B; black. Wall thickness of wrought-steel pipe shall comply with ASME B36.10M.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
2. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
3. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
4. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
5. Cast-Iron Flanges and Flanged Fittings: ASME B16.1, Class 125.
6. Joint Compound and Tape: Suitable for natural gas.
7. Steel Flanges and Flanged Fittings: ASME B16.5.
8. Gasket Material: Thickness, material, and type suitable for natural gas.

B. Hard Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), drawn temper.

1. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
2. Brazing Filler Metals: AWS A5.8, Silver Classification BAg-1. Filler metal containing phosphorus is prohibited.
3. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
4. Gasket Material: Thickness, material, and type suitable for natural gas.

C. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), annealed temper.

1. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
2. Brazing Filler Metals: AWS A5.8, Silver Classification BAg-1. Filler metal containing phosphorus is prohibited.

D. Tin-Lined Copper Tube: ASTM B 280, seamless, annealed, with interior tin-plated lining.

1. Mechanical Compression Fittings: Zinc lined, including seals compatible with gas in the piping, and approved by authorities having jurisdiction.

E. Corrugated Stainless Steel Tubing: ASTM A240 with PVC coating.

1. Brass fittings and nuts: ASTM B16 and ASTM A197.

2.5 PROTECTIVE COATING

A. Furnish pipe and fittings with factory-applied, corrosion-resistant polyethylene coating for use in contact with materials that may corrode the pipe.

2.6 PIPING SPECIALTIES

A. Flexible Connectors: ANSI Z21.24, copper alloy.

B. Quick-Disconnect Devices: ANSI Z21.41, convenience outlets and matching plug connector.

2.7 SPECIALTY VALVES

A. Valves, NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Valves, NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

C. Appliance Connector Valves: ANSI Z21.15 and CSA International listed.

1. Manufacturers:

a. American Valve Inc.
b. B&K Industries, Inc.
c. Brass Craft Manufacturing Co.
d. Cimberio Valves, S. p. A.
e. Conbraco Industries, Inc.; Apollo Div.
f. E. M. Plastic and Electric Products, Ltd.; Neo Valve Div.
g. JMF Company.
h. Jomar International Ltd.
i. Key Gas Components, Inc.
j. Legend Valve and Fitting, Inc.
k. McDonald, A. Y. Mfg. Co.
l. Mueller Co.; Mueller Gas Products Div.
m. Newman Hattersley Ltd.; Specialty Valves Div.
n. Robert Manufacturing Co.
o. State Metals, Inc.
p. Watts Industries, Inc.; Water Products Div.

D. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig (13.8-kPa) minimum pressure rating.

E. Gas Valves, NPS 2 (DN 50) and Smaller: ASME B16.33 and CSA International-listed bronze body and 125-psig (860-kPa) pressure rating.

1. Manufacturers:

    a. BMI Canada, Inc.
    b. Crane Valves.
    c. Dungs, Karl, Inc.
    d. Flow Control Equipment, Inc.
    e. Grinnell Corp.
    f. Honeywell International Inc.
    g. Jomar International Ltd.
    h. KITZ Corporation.
    i. Legend Valve and Fitting, Inc.
    j. Lyall, R. W. & Co., Inc.
    k. McDonald, A. Y. Mfg. Co.
    l. Milwaukee Valve Company.
    m. Mueller Co.; Mueller Gas Products Div.
    n. NIBCO INC.
    o. Red-White Valve Corp.
    p. Velan Inc.
    q. Watts Industries, Inc.; Water Products Div.

2. Tamperproof Feature: Include design for locking.

F. Plug Valves, NPS 2-1/2 (DN 65) and Larger: ASME B16.38 and MSS SP-78 cast-iron, lubricated plug valves, with 125-psig (860-kPa) pressure rating.

1. Manufacturers:

    a. Flow Control Equipment, Inc.
    b. Milliken Valve Co., Inc.
    c. Nordstrom Valves, Inc.
    d. Olson Technologies, Inc.; Homestead Valve Div.
    e. Walworth Co.

2. Tamperproof Feature: Include design for locking.

G. General-Duty Valves, NPS 2-1/2 (DN 65) and Larger: ASME B16.38, cast-iron body, suitable for fuel gas service, with "WOG" indicated on valve body, and 125-psig (860-kPa) pressure rating.

1. Gate Valves: MSS SP-70, OS&Y type with solid wedge.
2. Butterfly Valves: MSS SP-67, lug type with lever handle.

H. Automatic Gas Valves: ANSI Z21.21, with electrical operator for actuation by appliance automatic shutoff device.

1. Manufacturers:

    a. ASCO General Controls.
    b. ASCO Power Technologies, LP; Division of Emerson.
    c. ASCO Valve Canada, Division of Emerson Electric Canada Limited.
    d. Dungs, Karl, Inc.
    e. Eaton Corporation; Controls Div.

f. Eclipse Combustion, Inc.
g. GPS Gas Protection Systems Inc.
h. Honeywell International Inc.
i. Johnson Controls.

I. Electrically Operated Gas Valves: UL 429, bronze, aluminum, or cast-iron body solenoid valve; 120-V ac, 60 Hz, Class B, continuous-duty molded coil. Include NEMA ISC 6, Type 4, coil enclosure and electrically opened and closed dual coils. Valve position shall normally be closed.

1. Manufacturers:

a. ASCO General Controls.
b. ASCO Power Technologies, LP; Division of Emerson.
c. Dungs, Karl, Inc.
d. Eclipse Combustion, Inc.
e. Goyen Valve Corp.; Tyco Environmental Systems.
f. Magnatrol Valve Corp.
g. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Div.
h. Watts Industries, Inc.

2.8 SERVICE METERS

A. Service Meters: Positive-displacement type suitable for fuel gas service. Include metal case, temperature compensation, corrosion-resistant internal components, and flow registered in cubic feet (liters). Comply with local gas department requirements.

1. Manufacturers:

a. Diaphragm-Type Service Meters:

1) American Meter Company.
2) Badger Meter, Inc.; Utility Products Div.
3) Invensys.
4) National Meter Industries, Inc.
5) Schlumberger Limited; Gas Div.

b. Rotary-Type Service Meters:

1) American Meter Company.
2) Schlumberger Limited; Gas Div.

2. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
3. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
4. Type: ANSI B109.1, diaphragm, with capacities 500 cfh (3935 mL/s) and less.
5. Type: ANSI B109.2, diaphragm, with capacities more than 500 cfh (3935 mL/s).
6. Type: ANSI B109.3, rotary.

B. Turbine Meters: Axial-flow type suitable for fuel gas service. Comply with construction criteria for axial-flow, gas turbine meters in ASME MFC-4M. Include metal body, corrosion-resistant internal components, and flow registered in cubic feet (liters).

1. Manufacturers:

a. American Meter Company.
b. Invensys.

2. NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
3. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.

C. Service-Meter Bars: Malleable- or cast-iron frame for supporting service meter. Include offset swivel pipes, meter nuts with O-ring seal, factory- or field-installed dielectric unions, and threaded ends complying with ASME B1.20.1.

1. Manufacturers:

a. American Meter Company.
b. Lyall, R. W. & Co., Inc.
c. McDonald, A. Y. Mfg. Co.
d. Mueller Co.; Mueller Gas Products Div.
e. National Meter Industries, Inc.
f. Perfection Corporation.
g. Schlumberger Limited; Gas Div.

2. Exception: Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.

D. Service-Meter Bypass Fittings: Ferrous, tee, pipe fitting with integral ball check valve and capped side inlet for temporary fuel gas supply.

1. Manufacturers:

a. Lyall, R. W. & Co., Inc.
b. Williamson, T. D., Inc.

2.9 PRESSURE REGULATORS

A. Description: Single stage and suitable for fuel gas service. Include steel jacket and corrosion-resistant components, elevation compensator, and atmospheric vent. Comply with local gas department requirements.

1. Manufacturers:

a. Service Pressure Regulators:

1) American Meter Company.
2) Fisher Controls International, Inc.; Division of Emerson.
3) Invensys.

4) National Meter Industries, Inc.
5) Richards Industries, Inc.; Jordan Valve Div.
6) Schlumberger Limited; Gas Div.

b. Line Pressure Regulators:

1) American Meter Company.
2) Donkin, Bryan RMG Canada, Ltd.
3) Eclipse Combustion, Inc.
4) Fisher Controls International, Inc.; Division of Emerson.
5) Invensys.
6) Maxitrol Company.
7) National Meter Industries, Inc.
8) Richards Industries, Inc.; Jordan Valve Div.
9) Schlumberger Limited; Gas Div.

c. Appliance Pressure Regulators:

1) Canadian Meter Co., Inc.
2) Eaton Corporation; Controls Div.
3) Harper Wyman Co.
4) Maxitrol Company.
5) SCP, Inc.

2. NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel flanges and according to ASME B16.24 for copper and copper-alloy flanges.
3. Service Pressure Regulators: ANSI Z21.80. Include **100-psig- (690-kPa-)** minimum inlet pressure rating.
4. Line Pressure Regulators: ANSI Z21.80 with [**2-psig- (13.8-kPa-) minimum 5-psig- (34.5-kPa-) minimum**, **10-psig (68.9-kPa)**] inlet pressure rating.
5. Line Pressure Regulators: ANSI Z21.80 with 10-psig (68.9-kPa) inlet pressure rating, unless otherwise indicated.
6. Appliance Pressure Regulators: ANSI Z21.18. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.

B. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for fuel gas piping system to verify actual locations of piping connections before equipment installation.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Close equipment shutoff valves before turning off fuel gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section. Comply with local gas department requirements.

3.3 SERVICE-METER ASSEMBLY INSTALLATION

A. Install service-meter assemblies aboveground.

1. Set service-meter assembly on, or supported over, precast concrete bases. Excavate earth and make level beds to support bases. Set bases level with top surface projecting 3 inches (75 mm) above finished grade. Concrete bases are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Include gas valve or plug valve, strainer, ervice pressure regulator,[service-meter bar for service meter with connections NPS 1 (DN 25) and smaller, and service meter for each assembly.

C. Install gas valve or plug valve and strainer upstream from each service pressure regulator.

D. Install service pressure regulators with vent outlet turned down and with corrosion-resistant-metal insect screen.

E. Install pressure gage upstream and downstream from each service pressure regulator. Pressure gages are specified in Division 15 Section Plumbing - Meters and Gages.

F. Install service meters downstream from service pressure regulators.

1. Service meters with connections NPS 1 (DN 25) and smaller on meter bars.
2. Service meters with connections larger than NPS 1 (DN 25) supported from piping or set on concrete bases. Comply with local gas department requirements.

3.4 SERVICE ENTRANCE PIPING

A. Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.
1. Natural gas distribution system piping, service pressure regulator, and service meter are specified in Division 2 section “Natural Gas Distribution”.

B. Install dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Install shutoff valve downstream from and adjacent to dielectric fitting. Dielectric fittings are specified in Division 15 Section "Basic Plumbing Materials and Methods."

C. Install strainer upstream from each earthquake valve. Strainers are specified in Division 15 Section "Plumbing Specialties."

3.5 PIPING APPLICATIONS

A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.

B. Fuel Gas Piping, 2 psig (13.8 kPa) or Less:

1. **NPS 1/2 (DN 15)** and Smaller: **NPS 3/4 (DN 20)** steel pipe, malleable-iron threaded fittings, and threaded joints, Hard copper tube, copper fittings and brazed joints, Tin-lined copper tube, copper and mechanical compression fittings, and brazed joints, Corrugated, stainless-steel tubing system and threaded joints.

   a. Option: Soft copper tube, copper fittings, and brazed joints may be used for runouts at individual appliances.

2. **NPS 3/4 and NPS 1 (DN 20 and DN 25)**: Steel pipe, malleable-iron threaded fittings, and threaded joints, Hard copper tube, copper fittings, and brazed joints, Corrugated, stainless-steel tubing system and threaded joints.

   a. Option: Soft copper tube, copper fittings, and brazed joints may be used for runouts at individual appliances.

3. **NPS 1-1/4 to NPS 2 (DN 32 to DN 50)**: Steel pipe, malleable-iron threaded fittings, and threaded, steel welding fittings, and welded joints.
4. **NPS 2-1/2 (DN 65)** and Larger: Steel pipe, steel welding fittings, and welded joints.

C. Fuel Gas Piping 2 to 5 psig (13.8 to 34.5 kPa):

1. **NPS 4 (DN 100)** and Smaller: Steel pipe, malleable-iron threaded fittings, and threaded, steel welding fittings, and welded joints.
2. Larger Than NPS 4 (DN 100): Steel pipe, steel welding fittings, and welded joints.

D. Underground Fuel Gas Piping: Steel pipe, steel welding fittings, and welded joints. Encase in containment conduit.

E. Containment Conduits: Steel pipe, steel welding fittings, and welded joints.

F. Gas Service Piping at Meters and Regulators, More Than 5 psig (34.5 kPa): Steel pipe, steel welding fittings, and welded joints.

3.6 VALVE APPLICATIONS

A. Appliance Shutoff Valves for Pressure 0.5 psig (3.45 kPa) or Less: Appliance connector valve or gas stop.

B. Appliance Shutoff Valves for Pressure 0.5 to 2 psig (3.45 to 13.8 kPa): Gas stop or gas valve.

C. Appliance Shutoff Valves for Pressure 2 to 5 psig (13.8 to 34.5 kPa): Gas valve.

D. Piping Line Valves, NPS 2 (DN 50) and Smaller: Gas valve.

E. Piping Line Valves, NPS 2-1/2 (DN 65) and Larger: Plug valve or general-duty valve.

F. Valves at Service Meter, NPS 2 (DN 50) and Smaller: Gas valve.

G. Valves at Service Meter, NPS 2-1/2 (DN 65) and Larger: Plug valve.

3.7 PIPING INSTALLATION

A. Basic piping installation requirements are specified in Division 15 Section "Basic Plumbing Materials and Methods."

B. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.

1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.
2. In Floors: Gas piping with welded joints and protective wrapping specified in Part 2 "Protective Coating" Article may be installed in floors, subject to approval of authorities having jurisdiction. Surround piping cast in concrete slabs with minimum of 1-1/2 inches (40 mm) of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
3. In Floor Channels: Gas piping may be installed in floor channels, subject to approval of authorities having jurisdiction. Channels must have cover and be open to space above cover for ventilation.
4. In Partitions: Do not install concealed piping in solid partitions. Protect tubing from physical damage when installed inside partitions or hollow walls.

    a. Exception: Tubing passing through partitions or walls.

5. In Walls: Gas piping with welded joints and protective wrapping specified in Part 2 "Protective Coating" Article may be installed in masonry walls, subject to approval of authorities having jurisdiction.
6. Prohibited Locations: Do not install gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.

    a. Exception: Accessible above-ceiling space specified above.

C. Drips and Sediment Traps: Install drips at points where condensate may collect. Include outlets of service meters. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches (75 mm) long, and same size as connected pipe. Install with space between bottom of drip and floor for removal of plug or cap.

D. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels, unless indicated to be exposed to view.

E. Install fuel gas piping at uniform grade of 0.1 percent slope upward toward risers.

F. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

G. Connect branch piping from top or side of horizontal piping.

H. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.

I. Install corrugated, stainless-steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

J. Install strainer on inlet of each line pressure regulator and automatic and electrically operated valve.

K. Install pressure gage **upstream and downstream** from each line pressure regulator. Pressure gages are specified in Division 15 Section Plumbing - Meters and Gages.

L. Install flanges on valves, specialties, and equipment having NPS 2-1/2 (DN 65) and larger connections.

M. Install vent piping for gas pressure regulators and gas trains, extend outside building, and vent to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end.

N. Install containment conduits for gas piping below slabs, within building, in gastight conduits extending minimum of 4 inches (100 mm) outside building, and vented to atmosphere. Terminate vents with turned-down, reducing-elbow fittings with corrosion-resistant insect screens in large end. Prepare and paint outside of conduits with coal-tar, epoxy-polyamide paint according to SSPC-Paint 16.

3.8 JOINT CONSTRUCTION

A. Basic piping joint construction is specified in Division 15 Section "Basic Plumbing Materials and Methods."

B. Use materials suitable for fuel gas.

1. Brazed Joints: Make with brazing alloy with melting point greater than 1000 deg F (540 deg C). Brazing alloys containing phosphorus are prohibited.

C. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

3.9 HANGER AND SUPPORT INSTALLATION

A. Pipe hanger and support and equipment support materials and installation requirements are specified in Division 15 Section "Plumbing - Hangers and Supports."

B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (16 mm).

C. Install hangers for horizontal hard copper tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 (DN 10): Maximum span, 48 inches (1219 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1829 mm); minimum rod size, 3/8 inch (10 mm).
3. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
4. NPS 1 (DN 25): Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).

D. Install hangers for horizontal corrugated, stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8 and NPS 1/2 (DN 10 and DN 15): Maximum span, 48 inches (1219 mm); minimum rod size, 3/8 inch (10 mm).
2. NPS 3/4 and NPS 1 (DN 20 and DN 25): Maximum span, 72 inches (1829 mm); minimum rod size, 3/8 inch (10 mm).
3. Option: Support tubing from structure according to manufacturer's written instructions.

3.10 CONNECTIONS

A. Drawings indicate general arrangement of fuel gas piping, fittings, and specialties.

B. Install piping adjacent to appliances to allow service and maintenance.

C. Connect piping to appliances using gas with shutoff valves and unions. Install valve upstream from and within 72 inches (1800 mm) of each appliance. Install union downstream from valve.

D. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

E. Ground equipment according to Division 16 Section "Grounding and Bonding."

1. Do not use gas pipe as grounding electrode.

F. Connect wiring according to Division 16 Section "Conductors and Cables."

3.11 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator, and specialty valve.

1. Text: In addition to name of identified unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
2. Nameplates, pipe identification, and signs are specified in Division 15 Section "Plumbing - Identification."

3.12 PAINTING

A. Use materials and procedures in Division 9 painting Sections.

B. Paint exterior service meters, pressure regulators, and specialty valves.

1. Color: Gray.

3.13 FIELD QUALITY CONTROL

A. Test, inspect, and purge piping according to NFPA 54 and requirements of authorities having jurisdiction.

B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

C. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.

D. Verify correct pressure settings for pressure regulators.

E. Verify that specified piping tests are complete.

END OF SECTION 15194

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15240 - VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Vibration control.

B. Description of Work

1. It is the objective of this specification to provide the necessary design requirements for the control of excessive noise and vibration in buildings due to the operation of machinery or equipment, and/or due to interconnected piping, ductwork or conduit.

2. Provide vibration isolation systems, complete as shown and specified per Contract Documents.

3. The work of this section includes, but is not limited to, the following:

(a) Vibration isolation elements for piping and equipment;

(b) Equipment isolation bases;

(c) Piping flexible connections;

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 1 Specification Sections, apply to this Section.

B. Section 15010 - Basic Mechanical Requirements

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is a part of each Division 15000 Section.

1.3 REFERENCES

A. ASHRAE.

1.4 QUALITY ASSURANCE

A. Applicator: Products provided by company specializing in vibration isolation with ten years minimum experience.

B. All vibration isolation devices shall be the product of a single manufacturer. Products of other manufacturers are acceptable, provided that their systems comply with the design intent for system performance, static deflection and structural design of the base manufacturer.

C. The following are approved manufacturers, provided their systems strictly comply with the design intent for performance, deflection and structural capacity of this specification.

1.	Mason Industries, Inc.	Hauppauge, NY
2.	Vibration Mountings & Controls	Bloomingdale, NJ
3.	Kinetics Company,	Dunlin, OH
4.	Korfund Dynamics Corp.,	Bloomingdale, NJ
5.	Vibration Eliminator Co., Inc.,	Long Island City, NY
6.	Amber Booth,	Houston, TX

D. Vibration isolation firms having a minimum of ten (10) years experience in designing and installing vibration isolation systems shall be qualified to provide the materials and installation required by this section. Project listings shall be provided including geographical location and a reference contact.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

D. Vibration isolation equipment submittal drawings shall include the following information:

1. Isolation mounting deflections.

2. Spring diameters, compressed spring heights at rated load; solid spring heights, where steel spring isolation mountings are used.

3. Equipment operating speed.

E. In addition to the requirements on Mechanical General Provisions, the submittal material shall include copies of descriptive data for all products and materials including, but not limited to, the following:

1. <u>Descriptive Data</u>:

(a) Catalog cuts and data sheets on specific vibration isolators to be utilized showing compliance with the specifications.

(b) An itemized list showing the items of equipment or piping to be isolated, the isolator type and model number selected, isolator loading and deflection.

2. Shop Drawings:

(a) Drawings showing equipment base constructions for each machine, including dimensions, structural member sizes and support point locations.

(b) Drawings showing methods of suspension, support guides for piping and ductwork.

(c) Drawings showing methods for isolation of pipes and ductwork piercing walls and slabs.

(d) Concrete and steel details for bases, including anchor bolt locations.

PART 2 - PRODUCTS

2.1 FLOOR MOUNTING OF CENTRIFUGAL FANS AND TUBULAR ARRANGEMENT ONE FANS - MOUNTING TYPE I

A. Each such fan and driving motor shall be mounted on an integral one piece structural base, reinforced as necessary to prevent flexure of the base at start up and during operation of the fan. The unitized structural base for the fan and motor shall include motor slide rails. The structural steel frame shall be drilled and tapped to receive the fan and motor so that the frame shall act as a template. Provide vertical limit stops suitable for applicable wind loads where exposed.

B. The structural steel integral base shall be supported on steel spring mountings. These mountings shall be positioned in accordance with the weight distribution to ensure adequate deflection and vibration isolation. Housing or snubbing devices shall not be used to contain the isolation springs.

C. Isolator types shall be one of the following or as approved:

Type SLF	-	M.I.I.
Type OSK	-	V.E.C.
Type AN	-	V.M.C.I.

2.2 FLOOR MOUNTING OF CENTRIFUGAL FANS - MOUNTING TYPE II

A. Each such fan and motor shall be mounted on a reinforced spring supported concrete foundation. The foundation shall be poured within structural perimeter frame set on roofing paper. The structural perimeter frame shall be supplied by the vibration isolation vendor and shall incorporate equipment anchor bolt templates and mounting brackets for each base spring support. Spring supports shall be located under the brackets and shall incorporate a neoprene acoustical pad and leveling adjustment to raise the entire isolation base 1 inch above the foundation pad.

B. Concrete inertia base thickness shall be in accordance with the following schedule:

Motor Size	Minimum Inertia Block Thickness Required
Up to 50 HP	8"
60 to 75 HP	10"
100 HP & Greater	12"

C. Mounting assemblies shall be one of the following or as approved:

Type KSL	-	M.I.I.
Type AWPF	-	V.M.C.I.
Type SN-OSK	-	V.E.C.

2.3 FLOOR MOUNTING OF CENTRIFUGAL FANS - TYPE III

A. This equipment shall be mounted exactly as described for TYPE I except that mountings shall be neoprene-in-shear and one of the following or as approved:

Type ND	-	M.I.I.
Type RD	-	V.M.C.I.
Type 368SD	-	V.E.C.

2.4 MOUNTING OF PACKAGED AIR HANDLING UNITS, TUBULAR ARRANGEMENT 9 FANS, AND BELTED VENT SETS - MOUNTING TYPE IV

A. Each such equipment shall be mounted on neoprene-in-shear isolators. Mountings shall be one of the following or as approved:

Type ND	-	M.I.I.
Type RD	-	V.M.C.I.
Type 368SD	-	V.E.C.

2.5 MOUNTING OF FLOOR MOUNTED PACKAGED AIR HANDLING UNITS, DX UNITS AND COMPUTER ROOM AC UNITS - MOUNTING TYPE V

A. This equipment shall be mounted directly on stable bare steel spring isolators, except that where the units to be mounted are furnished with internal structural frames and external lugs (both of suitable strength and rigidity), or without any severe overhangs, no additional structural frame need be furnished and installed beneath the unit except minimum 4" housekeeping pad or as required for proper condensate drain. In any event, the motor shall be integrally mounted to the unit and shall be mounted on slide rails. Mounting types shall be as described for TYPE I.

B. Minimum static deflection shall be 1". See schedule.

2.6 MOUNTING OF CEILING SUPPORTED PACKAGED AIR HANDLING UNITS, TUBULAR ARRANGEMENT 9 FANS, & BELTED VENT SETS - MOUNTING TYPE VI

A. All such units shall be hung by means of vibration isolator hangers consisting of a steel housing or retainer incorporating a steel spring and neoprene mounting.

B. If the equipment to be mounted is not furnished with integral structural frames and external mounting lugs (both of suitable strength and rigidity), approved structural

sub-base shall be installed in the field which shall support the equipment to be hung and to which shall be attached to the hangers.

C. Isolators shall be one of the following or as approved:

Type 30N	-	M.I.I.
Type 30	-	V.M.C.I.
Type SNRC-4	-	V.E.C.

D. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4 inch maximum under fan operating conditions.

2.7 MOUNTING OF CEILING SUPPORTED PACKAGED AIR HANDLING UNITS, TUBULAR ARRANGEMENT 9 FANS AND BELTED VENT SETS - MOUNTING TYPE VII

A. This equipment shall be mounted exactly as described for TYPE VI except that mounting shall be one of the following, or as approved:

Type HD	-	M.I.I.
Type RHD	-	V.M.C.I.
Type CD	-	V.E.C.

B. Diagonal hanger rod isolators shall be provided as required to limit horizontal motion to 1/4 inch maximum under fan operating conditions.

2.8 MOUNTING OF CENTRIFUGAL PUMPS AND FLOOR-MOUNTED IN-LINE PUMPS - (GREATER THAN 3 HP)

A. Each pump with its driving motor shall be bolted and grouted to a spring supported concrete inertia base reinforced as required.

B. Each concrete base (rectangular or "T" shape) for horizontally split pumps shall include supports and base elbows for the suction and discharge connections. Base elbows shall be bolted and grouted to the concrete foundation.

C. Concrete inertia base thickness shall be in accordance with the following schedule:

Motor Size	Minimum Inertia Block Thickness Required
5 HP to 20 HP	6"
20 HP to 60 HP	8"
75 HP to 100 HP	10"
Greater than 100 HP	12"

D. The spring supported concrete inertia foundation shall be poured within structural perimeter frame (reinforced as necessary) of the required thickness indicated in the above schedule. The structural perimeter frame shall be equipped with height saving brackets and stable bare spring isolators having spring diameters no less than 0.8 of the compressed height of the spring at rated load. The mountings shall provide minimum static deflections as indicated on the schedule. The structural perimeter frame, mounting templates, saving brackets and spring system shall be provided as an assembly by the vibration control vendor.

E. Mounting assemblies shall be one of the following or as approved:

Type KSL	-	M.I.I.
Type AWPF	-	V.M.C.I.
Type SN-OSK	-	V.E.C.

2.9 MOUNTING OF CENTRIFUGAL PUMPS (3 HP or less)

A. Pumps 3 HP or less shall be bolted and grouted to rubber-inshear supported reinforced concrete inertia blocks that are a minimum of 6 inches thick. Rubber-in-shear isolators shall provide a minimum static deflection of 3/8 inch and shall be protected against corrosion. Mountings shall be as described for TYPE IV.

2.10 MOUNTING OF HUNG IN-LINE MOUNTED CENTRIFUGAL PUMPS: (GREATER THAN 5HP)

A. Provide hanger at adjacent pipe:

Type PC-30	-	M.I.I.
Type VSHL	-	V.M.C.I.

2.11 MOUNTING OF REFRIGERATION MACHINES AND BOILERS

A. Each machine (cooler-condenser drive-compressor) and boilers shall be resiliently supported on steel spring isolation mountings. The motor-compressor assembly shall be provided with a rigid steel structural base designed to withstand operating forces of the machine. Base shall be furnished as an integral part of the machine by the manufacturer.

B. Spring mountings shall incorporate unrestrained stable springs with built-in leveling device and resilient vertical limit stops to prevent spring elongation MORE THAN 1/8" when partial load is removed. The mountings shall also be capable of providing rigid anchor during erection of machine so that is can be erected at a fixed elevation. After equipment installation is complete and filled with water, the mountings are to be adjusted in accordance with the manufacturer's installation procedures.

C. Spring mountings shall provide a minimum of two inch static deflection for refrigeration machines and a minimum of one inch for boilers and shall have two layers of acoustical neoprene base pads separated by 16 g. sheet metal. Mountings shall be one of the following or as approved:

Type SLR	-	M.I.I.
Type AWR	-	V.M.C.I.
Type WSCL	-	K.D.C.
Type KW	-	V.E.C.

2.12 PIPING GUIDES

A. Type ADA Mason Industries or as approved.

2.13 ACOUSTICAL ANCHORS

A. Type VPA Mason industries or as approved.

2.14 PIPE SUPPORTS WITHIN SHAFTS

A. Type W - MII
Shearflex - VMCI
Type 200N - VEC

2.15 PIPING SUPPORTS

A. All water piping hanger rod isolators shall be one of the following or as approved:

Type PC30 - M.I.I.
Type VSHL - V.M.C.I.
Type TK - V.E.C.
Type VXPM - K.D.C.

B. Floor supported water piping shall be mounted on one of the following or as approved:

Type SLR - M.I.I.
Type AWR - V.M.C.I.
Type KW - V.E.C.

C. Floor mounted strainer and storage tank shall be mounted on one of the following or as approved:

Type SLR - M.I.I.
Type AWR - V.M.C.I.
Type KW - V.E.C.

PART 3 - EXECUTION

3.1 GENERAL

A. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

B. All concrete foundations and supports (and required reinforcing and forms) will be furnished and installed by another trade. However, this trade shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although another trade will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, vibration isolation devices, etc.

C. All floor-mounted equipment shall be erected on minimum 4" high concrete pads over the complete floor area of the equipment, unless specified to the contrary herein. Wherever hereinafter vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted upon 4" high concrete pads unless specified to the contrary herein.

D. The vibration isolation systems shall be guaranteed to have the deflection indicated on the schedule on the drawings. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer's instructions.

E. The installed vibration isolation system for each floor or ceiling supported equipment shall have a maximum lateral motion under equipment start-up or shut down conditions of 1/4 inch. Motions in excess shall be restrained by approved spring type mountings.

F. All mounting systems exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

G. Where steel spring isolation systems are described in the specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.

3.2 SUPPORT OF PIPING

A. The following water piping shall be resiliently supported:

1. All piping in equipment room.

2. Piping outside of equipment room within 50 feet or 100 diameters whichever is greater of connected rotating equipment.

3. All piping where exposed on roof.

4. Boiler breeching, emergency generator exhaust piping.

B. Resilient diagonal mountings or other approved devices shall be provided as required to limit piping motion due to equipment startup or shut down, to a maximum of 1/8 inch.

C. Water piping hanger rod isolators shall contain a steel spring in series with a 1/4 inch acoustical neoprene pad within a steel box retainer. The hanger rod isolator assembly shall be rigidly supported from the building structure. The installed hanger rod supported from the spring sub assembly shall not contact the steel box retainer and clearances in the isolator design shall be capable of accepting a 15 misalignment in any direction from the vertical.

D. The steel spring element of the assembly shall be designed to have a minimum surge frequency of 340 HZ and a minimum deflection of 3/4 inch.

E. Hanger rod isolators for steam and condensate piping including steam pressure reducing valve stations shall be supported by meals of neoprene-in-shear mountings providing a minimum static deflection of ½ inch.

F. Where supplementary steel is required to support piping, the supplementary steel shall be sized so that maximum deflection between supports does not exceed 0.08 inches and shall be resiliently supported from the building structure with mountings as described above. Supported piping from the supplementary steel shall be rigidly suspended or supported.

G. Precompressed type hanger rod isolators shall be provided for all water piping greater than 12 inch diameter and all supplementary steel supports. The precompression shall be factory set at 75% of rated deflection.

H. Where isolated water piping 8" and larger is supported directly below exposed steel beams, attachment to the beam shall be made by means of welded channel beam attachments located directly under the web of the beam. For piping 6" and smaller beam clamps may be used in lieu of welding subject to approval of beam clamp selection.

3.3 MAIN CHILLED & HOT WATER PIPING ANCHORS, GUIDES & SUPPORTS

A. Pipe riser guides, anchors and supports including piping anchors in mechanical equipment rooms or occupied spaces shall be isolated from the building structure such that there shall be no direct metal to metal contact of the piping with the building structure.

3.4 PIPING GUIDES

A. Steel guides shall be welded to the pipe at a maximum spacing of 90°. The outside diameter of the opposing guide bars shall be smaller than the inside diameter of the pipe riser clamp in accordance with standard field construction practice. Each end of the pipe guide shall be rigidly attached to an all directional pipe anchor isolation mounting which in turn, shall be rigidly fastened to the steel framing within the shaft.

B. The all directional pipe anchor isolation mountings shall consist of a telescoping arrangement of two sizes of steel tubing separated by a minimum of ½ inch thick heavy duty neoprene and canvas duck isolation pad. Vertical restraints shall be provided by similar material arranged to prevent vertical travel in either direction. The allowable load on the isolation material shall not exceed 500 psi.

C. Mountings shall be Type ADA - Mason Industries, Inc., or as approved.

D. Low temperature piping guides shall be constructed with a 360 10 gauge metal sleeve around the piping. The thermal insulation requirements for the piping shall be provided between the piping and the sleeve. Heavy duty neoprene and canvas duck isolation pad of thickness equal to thermal insulation requirements shall space the metal sleeve away from the piping with urethane or other suitable thermal insulation provided in the voids between the pipe-sleeve and isolation pan material. The metal sleeve outside diameter shall be smaller than the pipe riser clamp inside diameter in accordance with standard field construction practice. The pipe riser clamp shall be rigidly attached to the steel framing within the shaft.

3.5 ANCHORS

A. The pipe riser clamp at anchor points, shall be welded to the pipe and to pairs of vertical acoustical pipe anchor mountings which in turn, shall be rigidly fastened to the steel framing in the pipe shaft.

B. Acoustical pipe anchor mountings shall be Type VPA Mason Industries, Inc., or as approved.

3.6 SUPPORTS

A. Piping supports within shafts shall be provided with suitable bearing plates and two layers of 1/4 inch thick ribbed or waffled neoprene pad loaded for 50 psi maximum. The isolation pads shall be separated with 1/4 inch steel plate.

B. The isolation pads shall be one of the following or as approved:

Type W	-	M.I.I.
Type Shearflex	-	V.M.C.I.
Type 200N	-	V.E.C.

C. Piping isolation supports at the base of risers shall be two layers of ½ inch thick heavy duty neoprene and canvas duck isolation pad separated by 1/4 inch thick steel plate. Suitable bearing plates sized to provide a pad loading of 500 psi maximum shall be provided. The stanchion between the pipe and isolation support shall be welded to the pipe and welded or bolted to the isolation support. The isolation support shall be bolted to the floor slab with resilient sleeves and washers.

D. All pipe support resilient materials shall be HL Mason Industries, Inc., or as approved.

3.7 SHEET METAL & PIPING PENETRATIONS OF SHAFTS, FLOOR SLAB AND/OR PARTITIONS

A. There shall be no direct contact of Sheet Metal or piping with shaft walls, floor slabs and/or partition. All uninsulated sheet metal or piping shall be packed with caulking the full depth of the penetration.

3.8 SCHEDULE

A. See drawings for schedule of equipment

B. Provide vibration isolation per the Schedule below.

Equipment	Base Type	Isolator Types	Static Defl (in.)	Mason Ind. Type (5)
Fans (including AHU) Floor/Roof Supported VFD below 300 rpm 301 - 450 rpm 451 - 600 rpm 601 - 750 rpm 751 - 850 rpm 851 greater Suspended	Per Mfr. (7)	Spring Sprg/Neop	 (9) 4.0 3.0 3.5 2.0 1.5 1.0 (above+0.25)	SLF 30N
Mechanical and Domestic Pump (8) 5HP - greater	Conc. Iner.	Spring	2.0	KSL
Less than 5HP	Steel	Neoprene	0.50	MND
Associated equipment (assoc. w/ pumps and piping)	Per Mfr.	(1)	(1)	
Air Cooled Chillers	Per Mfr.	Sprng	2.0	SLR
Mechanical and Domestic Piping (3) Floor Supported Suspended Steam	as req'd	 Spring Sprg/Neop Neoprene	 1.0 1.25 0.35	 SLR 30N HD or ND
Generator (2)	Per Mfr.	Restr. Spring	1.0	SLR
Transformers (interior Dry Type) Floor Mounted (4) Suspended	 Per Mfr. Per Mfr.	 Neoprene Neoprene	 0.50 0.50	 ND HD

(1) Same as connected piping and pump.
(2) Manufacturer's standard springs.
(3) All water and steam piping with MER, but not less than 50 feet of equipment or pressure reducing stations, and all piping 4 inches and larger within and/or suspended from occupied floor.
(4) Internal isolation for transformer cores complying with the above tabulated isolation type and ratings is acceptable.
(5) All isolation devices are to be Mason Industries or approved equal.
(6) Seismic restraints as required for project are to be separate of vibration isolation devices, and shall not degrade vibration isolation. Extent and type of seismic restraints by others.
(7) Vibration isolation scheme to consider fan operating force and provide thrust restraint and/or concrete inertia base in order to limit movement of fan to 1/4 inch at any operating point. Thrust restraints to have the same deflection as vibration isolation devices.
(8) In-line pumps to be mounted per manufacturer's recommendations.
(9) Isolator static deflection should be based on the VFD motor's lowest expected operating speed, per suggested schedule.

END OF SECTION 15240

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15250 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Insulation for ductwork, piping, and equipment as described.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section 15010 - Basic Mechanical Requirements

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is a part of each Division 15000 Section.

E. Section 09900 - Painting: Painting insulation jackets.

1.3 REFERENCES

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ASTM C335 - Thermal Conductivity of Pipe Insulation.

C. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

D. ASTM E84 - Surface Burning Characteristics of Building Materials.

E. NFPA 255 - Surface Burning Characteristics of Building Materials.

F. UL 723 - Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with three years minimum experience.

B. Insulation Materials: Insulation materials shall be manufactured at facilities certified and registered to conform to ISO 9000 Quality Standard.

C. Insulation shall have <u>composite</u> (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to the insulation) fire and smoke hazard ratings as tested by procedure ASTM E.84, NFPA 255 or UL 723 not exceeding:

Flame Spread: 25

Smoke Developed: 50

Accessories such as adhesives, mastics, cements, and tapes for fittings shall have the same component rating as listed above. All products or their shipping cartons shall bear a label indicating that flame and smoke ratings do not exceed requirements. Treatment of jackets or facings to impart flame and smoke-safety shall be permanent. The use of water soluble treatments is prohibited.

D. Asbestos shall not be used in the manufacture of insulation products.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART 2 - PRODUCTS

2.1 GENERAL

A. All fiberglass insulation products, specified herein, shall be manufactured from recycled glass with a minimum of 30% post consume recycled content by weight. Contractor shall submit manufacturers certification of recycled content for approval.

1. All fiberglass insulation products used for ductwork, piping, or equipment insulation shall be formaldehyde free.

B. Adhesives

1. All adhesives used on this project shall be of the type having limited capability to emit volatile organic compounds. Each adhesive shall meet the following emission factor limits:

Total VOC's	10.0 mg/m3/hr.
Formaldehyde	0.05mg/m3/hr.
2-Ethyl-1-Hexanol	3.0 mg/m3/hr.

2. The contractor shall submit a cut sheet and MSDS sheet for each adhesive to be used in the building mechanical system, highlighting VOC limits.

C. Sealants

1. All sealants used in mechanical systems shall be of the low volatile organic compound emitting type. All sealants shall have emission characteristics that do not exceed a VOC limit of 250 g/L. The contractor shall provide a cut sheet and MSDS sheet for each sealant to be used in the building mechanical system, highlighting VOC limits.

2.2 INSULATION FOR PIPING

A. Piping systems described shall be insulated as follows, including all flanges, fittings, valves, expansion joints, vents, drains and all other parts of the system. All piping subject to freezing such as in outdoor air or discharge plenums or outdoors shall be insulated with a minimum of 2" insulation.

B. Insulation on all cold surfaces must be applied with a continuous unbroken vapor seal. Hangers, supports, anchors, etc. that are secured directly to cold surfaces must be adequately insulated and vapor sealed to prevent condensation.

C. Insulation for outdoor piping shall be as described in Weatherproofing Finishes for Outdoor Insulation.

D. Schedule of Insulation Type and Minimum Thickness:

Piping System	Thickness	Type
Chilled water supply and return. Up to 1½" 2" and over	 1" 1-1/2"	 P-1 P-1
Hot-cold supply and return, mains and run outs ½" (45ºF to 170ºF) up to 1½" I.P.S. 2" to 6" I.P.S. Over 6" I.P.S.	 1-1/2" 2" 2-1/2"	 P-1 P-1 P-1
Refrigerant suction	1-1/2"	P-1
Outdoor domestic water. (for lengths see Plumbing Drawings)	2"	P-1
Drain from A.C. units, fan coil units, cooling coil drip pans, and miscellaneous piping subject to sweating.	½"	P-2
Domestic make-up water	1/2"	P-2
Low pressure steam (0 to 15 psig) condensate return, humidification steam and condensate pump discharge up to 1½" I.P.S. 2" to 6" I.P.S. Over 6"	 1½" 3" 3½"	 P-3 P-3 P-3
Steam humidification piping	Same as low pressure steam piping	Same as low pressure steam piping
Snow melting supply and return. Up to 1½" 2" and above	 1" 2"	 P-3 P-3

Piping System	Thickness	Type
Fuel oil supply and return.	1"	P-3
Steam safety and relief.	1"	P-3
Engine exhaust and muffler.	3"	P-4

E. Type P-1 Glass Fiber for Cold Pipes

1. Insulation shall be glass fiber with a maximum K factor of .24 at 75 degrees F mean temperature with factory applied all-service jacket.

2. Insulation shall be rigid, molded, one-piece, fiberglass insulation that is bonded with thermosetting resin, similar to Schuller Micro-Lok with AP-T Plus Jacket.

3. The longitudinal lap of the All Purpose Jacket shall have a pressure sensitive tape lap sealing system. Butt joints shall be sealed using manufacturer supplied butt strips.

4. All fittings, valves, flanges and pipe terminations shall be fully insulated with glass fiber insulation and molded fitting covers. Thickness of insulation shall be at least as great as that on the adjoining pipe and shall be vapor sealed.

5. Flange insulation shall extend a minimum of 1" beyond the end of the bolts, and the bolt area shall be filled with Mineral Wool Cement.

F. Type P-2 Glass Fiber for Anti-Sweat Insulation:

1. Same material and application techniques as for Type P-1.

G. Type P-3 Glass Fiber for Hot Pipes:

1. Insulation shall be glass fiber with a maximum K factor of .24 at 75 degrees mean temperature and shall be furnished with a factory applied all-service jacket.

2. Insulation shall be capable of continuous service at a pipe temperature of 450°F without oxidation, burnout of binders, or development of odors or smoke.

3. Insulation shall be rigid, molded, one piece fiberglass insulation that is bonded with thermosetting resin, similar to Schuller Micro-Lok with AP-T Plus Jacket.

4. The longitudinal lap of the All Purpose Jacket shall have a pressure sensitive tape sealing system. Butt joints shall be sealed using manufacturer supplied butt strips.

5. All fittings, valves, flanges and pipe terminations shall be fully insulated with glass fiber insulation and molded fitting covers. Thickness of insulation shall be at least as great as that on the adjoining pipe.

6. Flange insulation shall extend a minimum of 1" beyond the end of the bolts, and the bolt area shall be filled with Mineral Wool Cement.

H. Type P-4 Calcium Silicate Pipe Insulation:

1. Insulation shall be 11 lbs per cu. ft. density molded hydrous calcium silicate with a maximum K factor of 0.42 at 200 degrees F. mean temperature. Insulation shall be fastened in place with 16 gauge copper-clad wire on l8" maximum centers.

(a) Fittings and valves for pipe sizes smaller than 4" shall be insulated and finished with Insulating and Finishing Cement to a thickness equal to the adjoining pipe insulation. Fittings and valves for pipe sizes 4" and larger shall be insulated with segments of the molded insulation wired securely in place and finished with a smoothing coat of finishing cement.

I. Provide insulation of thickness shown for piping which is electrically traced. Note that insulation is to be provided by this trade over electric tracing provided by the electrical trade. Insulation Types are as specified under "Insulation For Piping".

1. The following piping shall be specially insulated:

(a) Outdoor Condenser Water

(b) Outdoor Domestic Water

2. Staples for fastening shall not be used in order to prevent possible short circuiting of electric wires. Use stainless steel bands.

3. All piping shall be insulated as described under "Insulation For Piping" except thicknesses shall not be less than as follows:

2½" for all pipe sizes.	-20ºF OUTDOOR DESIGN

2.3 INSULATION FOR SHEET METAL

A. Note that ductwork and casings which are acoustically lined, as described elsewhere, need not be insulated on the exterior.

B. The exception to the above is that acoustically lined ductwork above roof shall be insulated on the exterior.

C. Insulate sheet metal as follows:

1. All air conditioned and/or heated low pressure supply ductwork from fan discharge and from devices which reduce air pressure to diffusers, grilles and registers including diffuser plenums - 1-1/2" Type D-1 for round ducts and concealed rectangular ducts - 1" Type D-2 for exposed rectangular ducts.

   (a) Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps), diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

2. All return air ductwork in non-conditioned spaces shall be insulated similar to low pressure supply ductwork.

   (a) Ceilings of conditioned spaces shall not require return ductwork insulation except for ceiling space located below roofs where return ductwork shall be insulated similar to low pressure supply ductwork.

   (b) Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps), diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

3. All medium pressure ductwork from fan discharge to any air terminal device which reduces air pressure -1-1/2" Type D-1 for round ducts and concealed rectangular. 1" Type D-2 for exposed rectangular ducts. All low pressure ductwork from air terminal device which reduces pressure to diffusers, grilles, and registers - 1-1/2" Type D-1.

   (a) Note that insulation (with vapor barrier) shall be continuous across all duct joints, hot water reheat coil pipe bends (insulated end caps) diffusers, etc. so as to provide a continuous, fully insulated with uninterrupted vapor barrier from the fan discharge to the diffusers.

4. Ducts and sheet metal plenums behind louvers containing all or a percentage of outside air on inlet side of air handling units and ventilation fans - 2" Type D-2.

5. All supply air sheet metal plenums - 2" Type D-2.

6. Outdoor ducts whether acoustically lined or not shall be insulated with 2" thick type D-2 and then weather proofed as specified under Weatherproofing Finishes for Outdoor Insulation. Exceptions: Toilet exhaust, general exhaust, smoke exhaust and stair pressurization ductwork.

7. Exhaust air ductwork from automatic dampers to discharge louvers (including sheet metal plenums behind louvers) - 2" type D-2.

8. Non air conditioned and non heated outside air supply (except in unheated areas such as garages) - 2" type D-1 for concealed ducts, 2" type D-2 for exposed ducts.

9. Non heated air exhaust (i.e., unheated garage, etc.) running through heated or air conditioned spaces - 2" type D-3 for concealed ducts, 2" type D-4 for exposed ducts.

10. All outside air supply (other than garage) - 2" Type D-2.

11. Exhaust air ductwork from discharge of emergency generator fan to louver (including duct plenum behind louver) - 2" Type D-2.

D. Type D-1 Flexible Duct Insulation With Vapor Barrier

1. Flexible duct insulation shall be 1 lb per cu. ft. density glass fiber with a maximum K factor of 0.29 at 75 degrees F. mean temperature, with reinforced foil-faced, flame resistant kraft vapor barrier.

2. Insulation shall be secured with duct adhesive. All joints shall be sealed by adhering a 2" sealing lap at all joints with vapor barrier adhesive or 3" strips of vapor barrier jacket applied with vapor barrier adhesive. Insulation shall then be fastened with 16 gauge copper-clad wire or fiberglass cord on 12" centers. On ducts over 24" wide, welded pins & clips shall be used on the underside.

3. Exposed round shall have a white vinyl reinforced foil vapor barrier. Application same except wires shall be omitted and blanket shall be secured by stapling 2" longitudinal lap. Staples shall be coated with vapor barrier coating.

E. Type D-2 Rigid Duct Insulation With Vapor Barrier:

1. Rigid duct insulation shall be 4.2 lbs per cu. ft. density glass fiber with maximum K factor of .24 at 75 degrees F mean temperature with vapor barrier facing.

2. Insulation shall be impaled over welded pins applied to duct surface on 12" to 18" centers. Use a minimum of two rows of fasteners on each side of duct. Secure insulation with suitable speed washers or clips firmly imbedded into insulation.

3. All joints and voids in the insulation shall be filled with Mineral Wool Cement. All joints, speed washers and breaks in the vapor barrier shall be sealed with 3" wide strips of the vapor barrier facing adhered with vapor barrier adhesive.

4. Exposed duct work shall have a white reinforced foil vapor barrier facing. Care shall be taken in sealing joints speed washers, etc. with matching strips of vapor barrier to insure good appearance.

F. Type D-3 Flexible Duct Insulation For Hot Ducts

1. Flexible duct insulation shall be 1 lb per cu. ft. density glass fiber with a maximum K factor of 0.29 at 75 degrees F. mean temperature.

2. Insulation shall be secured with a Benjamin-Foster 85-20 adhesive. Butt all edges of insulation on exposed ducts and lap all edges of insulation 2" on concealed ducts. Insulation shall then be fastened with 16 gauge copper-clad wire on 12" centers.
3. Exposed ducts shall have white, reinforced foil facing. Secured by stapling a 2" longitudinal lap and eliminate wire.

G. Type D-4 Rigid Duct Insulation For Hot Ducts

1. Rigid duct insulation shall be 4.2 lbs per cu. ft. density glass fiber with maximum K factor of .24 at 75 degrees F mean temperature with fire retardant vapor barrier facing.

2. Insulation shall be impaled over welded pins applied to duct surface on 12" to 18" centers. Use a minimum of two rows of fasteners on each side of duct. Secure insulation with suitable speed washers or clips firmly imbedded into insulation.

3. All joints and voids in the insulation shall be filled with Mineral Wool Cement.

4. Exposed ductwork shall have a white vinyl reinforced foil vapor barrier facing. Care shall be taken in sealing joints speed washers, etc. with matching strips of vapor barrier to insure good appearance.

2.4 INSULATION FOR EQUIPMENT, BREECHINGS, & KITCHEN EXHAUST

A. The following Cold Equipment shall be insulated with Vapor Barrier Board Insulation using Type E-1 insulation.

1. Centrifugal Refrigeration Equipment - 2 inches.

2. Evaporators, Dehumidifiers and Exchangers - 2 inches.

3. Chilled Water Pumps, Secondary Water Pumps, and Expansion Tanks - 1 inch.

4. Single Inlet Fans Downstream of Cooling Coils - 2 inches.

B. The following Hot Equipment shall be insulated with Semi-Rigid Board Insulation using Type E-2 Insulation.

1. Hot Water Expansion Tanks -)1 inch.
) 250°F max.
2. Hot Water Converters and)Generators - 1 inch.
) 250°F max.

C. The following Equipment & Systems shall be insulated with high temperature block insulation using Type E-3 insulation.

1. Boilers - 2 inch.) Package Boilers are) Usually Insulated) at Factory

2. Boiler Breechings - 2 inch.

3. Kitchen Range Exhaust Ducts, Casings, and Fans - 2 inch.

4. Branch ducts from other equipment in kitchen area such as dishwasher, etc. - 1 inch.

D. Type E-1 Glass Fiber Rigid Equipment Insulation With Vapor Barrier:

1. Insulation shall be 4.2 lb. per cu. ft. density glass fiber with vapor barrier facing and having a maximum K factor of 0.24 at 75 degrees F mean temperature.

2. Insulation shall be firmly held in place with copper clad wire or pins and clips on 12" centers.

3. All joints and voids in the insulation shall be filled with mineral wool cement. All joints and breaks in the vapor barrier shall be sealed with strips of the vapor barrier facing adhered with vapor barrier adhesive.

4. Finish shall consist of imbedding an open weave glass fabric (20 x 20) into wet coating of lagging adhesive over-lapping the seams at least 2". A finish coat of lagging adhesive shall then be applied.

5. Sections of equipment requiring periodic servicing such as heads and pumps shall be insulated with sheet metal covers lined with 4.2 lb. density fiber glass board.

E. Type E-2 Glass Fiber Rigid Equipment Insulation:

1. Insulation shall be 4.2 lb. per cubic foot density glass fiber having a maximum K factor of .24 at 75 degrees F mean temperature.

2. Insulation shall be firmly held in place with copper-clad wire or pins and clips on 12" centers.

3. All joints and voids in the insulation shall be filled with mineral wool cement.

4. Over the insulation apply 1" galvanized wire netting secured to the bands or wires and pulled down tight. They apply 1 coat of Insulating and Finishing Cement troweled to a smooth finish.

5. Exposed equipment shall be finished by embedding open weave glass fabric (20 x 20) into wet coating of lagging adhesive overlapping seams 2". A finished coat of lagging adhesive shall then be applied.

6. Sections of equipment requiring periodic servicing such as heads and pumps shall be insulated with sheet metal covers lined with 4.2 lb. density fiber glass board.

F. Type E-3 High Temperature Block Insulation:

1. High temperature insulation shall be 11 lbs. per cu. ft. density molded hydrous calcium silicate with a maximum K factor of 0.42 at 200 degrees F mean temperature.

2. Insulation shall be securely wired in place with copper clad wire or galvanized steel bands (½" x .015) on 12" centers.

3. All joints and voids of insulation shall be filled and pointed with mineral wool cement.

4. Over the insulation apply 1" galvanized wire netting secured to the bands or wires and pulled down tight. They apply 1/4" thick coat of Insulating and Finishing Cement trowelled to a smooth finish. This applies to both exposed and concealed work.

5. For kitchen exhaust ducts exposed in finished spaces cover the cement finish with glass cloth set in adhesive.

6. Sections of equipment requiring periodic servicing shall be insulated with aluminum covers lined with the same thickness of material as the adjoining insulation.

2.5 WEATHERPROOFING FINISHES FOR OUTDOOR INSULATION

A. Outdoor Round Duct:

1. Ductwork shall be insulated as specified under “Insulation for Sheet Metal” and provided with a weatherproof finish as described herein.

2. Finish with a .016" thick aluminum jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturer's recommendation.

3. Where field applied jacketing must be used it shall be applied with 2" overlap facing down from the weather and shall be secured with an aluminum band (½" x .020"), and seals applied on 12" centers with bands applied directly over butt overlaps. As an alternate the jacketing may be applied with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Insul-Coustic Sure Joint 405, or BF 30-45 Foam Seal.

4. Fittings shall be insulated and finished with mitered sections of the insulation with factory attached aluminum jackets installed per manufacturer's recommendation.

B. Outdoor Equipment, Rectangular Duct Work and Irregular Surfaces:

1. Ductwork, equipment and irregular surfaces shall be insulated as specified under this section and provided with a weatherproof finish as described herein.

2. The surfaces shall be weather protected with two coats of Insulcoustic VI-AC Mastic, I-C 551, or Benjamin Foster GPM Mastic with open weave glass cloth membrane imbedded between the coats. The total thickness of the coating shall be a minimum of 1/8".

C. Outdoor Piping

1. Piping shall be insulated as specified under “Insulation for Piping” and provided with a weatherproof finish as described herein.

2. Finish with a .016" thick aluminum jacket which has a factory applied moisture barrier. For all applications where it is available, the jacketing shall be factory attached to the insulation and installed per manufacturer's recommendation.

3. Where field applied jacketing must be used, it shall be applied with 2" overlap facing down from the weather and shall be secured with an aluminum band (½" x .020"), and seals applied on 12" centers with bands applied directly over butt overlaps. As an alternate, the jacketing may be applied with Pli-Grip Rivets. Where jacketing is cut out or abuts an uninsulated surface, the joint shall be sealed with Insul-Coustic Sure Joint 405, or BF 30-45 Foam seal.

4. Fittings and valves shall be insulated and finished with mitered sections of the insulation with factory attached aluminum jackets installed per manufacturer’s recommendation.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install materials after ductwork has been tested and approved.

B. Clean surfaces for adhesives.

C. Do not startup and operate chilled water system prior to completion of insulation for the entire chilled water piping system and complete closure of building from the external atmosphere.

D. Do not operate air handling system with conditioned air prior to completion of insulation of the entire duct distribution system for that air handling system.

3.2 INSTALLATION

A. Insulation shall be applied on clean dry surfaces, after inspection and release for insulation application.

B. Insulation shall be continuous through wall and ceiling openings and sleeves. Where insulated piping or ductwork pierces fire rated partitions, walls, and floors,

substitute anhydrous calcium silicate insulation with vapor barrier in lieu of fiberglass for a minimum of 8" from wall, to produce a hard surface for fire resistive packing.

C. Insulation on cold surfaces where vapor barrier jackets are used shall be applied with a continuous, unbroken vapor seal. Hangers, supports, anchors, etc., that are secured directly to cold services shall be adequately insulated and vapor sealed to prevent condensation.

D. Inserts shall be installed at hangers for cold insulated piping. Inserts between the pipe and pipe hangers shall consist of rigid pipe insulation of equal thickness to the adjoining insulation and shall be provided with vapor barrier where required. Inserts shall have sufficient compressive strength so that when used in combination with a sheet metal shield, they support the weight of the pipe and the fluid in it without crushing the insulation.

3.3 SCHEDULE

A. As described under products.

END OF SECTION 15250

NEW PASSENGER TERMINAL
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DULUTH, MINNESOTA

SECTION 15260 - ACOUSTICAL DUCT LINING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork acoustical lining.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section 15010 - Basic Mechanical Requirements

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is a part of each Division 15000 Section.

1.3 REFERENCES

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

C. ASTM E84 - Surface Burning Characteristics of Building Materials.

D. NFPA 255 - Surface Burning Characteristics of Building Materials.

E. UL 723 - Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork acoustic lining application with three years minimum experience.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials and thickness for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

D. Approval of the above named products is contingent upon samples to be submitted to our office. Also, after approval, contractor shall furnish to the job site a section of the material applied to a 24 x 24 section of sheetmetal. This will be maintained at the job site for quality control.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Acoustical Duct Lining Materials: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Owens Corning Aeroflex

2. Manville Linacoustic

3. CertainTeed Ultralite 150 (substitutions are not acceptable).

2.2 MATERIALS

A. Acoustical Duct Lining density shall be 1½ lb. per cubic foot, minimum thickness of 1", unless specified greater.

B. Lining shall have a composite fire and smoke hazard rating (UL 723) not exceeding:

Flame Spread:	25
Smoke Developed:	50

C. Asbestos shall not be used in the manufacture of lining products.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean surfaces before applying adhesives.

3.2 INSTALLATION

A. This contractor shall make all necessary repairs to the lining where improperly applied, or damaged.

B. Duct sizes shown on drawings shall be considered as clear inside dimensions.

C. A perforated inner metal liner consisting of 22 ga. galv. steel with 3/32" dia. holes on 3/16" or 1/4" centers or the equivalent aluminum shall be installed in every one of the following conditions. (Fastening for metal liners shall only be by welded stud. Where duct cross section exceeds 48" the top section shall be fastened with twice the amount of clips.)

1. Where shown on drawings.
2. Where called for elsewhere in these documents.
3. Where the duct can be walked on, metal liners shall be used on bottom portions.
4. Where the velocity in the duct exceeds 3500 FPM.

D. The leading edge of acoustical duct liner (facing into the air flow) of each non abutting section such as the first section facing into the fan, or the first section after

a sound trap, or ducts having a velocity in excess of 3,500 FPM shall have a metal nosing.

E. All portions of duct designated to receive acoustical duct liner shall be completely covered with acoustical duct liner. Transverse joints shall be neatly butted and there shall be no interruptions or gaps. The black coated surface of the acoustical duct liner shall face the air stream. The acoustical duct liner shall be adhered to the sheet metal with 100% coverage of adhesive and all exposed leading edges and all transverse joints coated with adhesive. Adhesive shall conform to Adhesive and Sealant Council Standards for Adhesives for duct liner; ASC-C-7001C-1972. The acoustical duct liner shall be additionally secured with mechanical fasteners (Mechanical fasteners shall conform to Mechanical Fastener Standard MF-1-l971, available from Sheet Metal and Air Conditioning Contractors National Association), except that gripnails or the equivalent shall not be allowed. Acoustical duct liner shall be cut to assure overlapped and compressed longitudinal corner joints. Fasteners shall start within 3" of the upstream transverse edges of the liner and 3" from the longitudinal joints and shall be spaced as recommended by SMACNA.

3.3 SCHEDULE

A. The following items shall be acoustically lined. Where distances of lining are indicated, the intent is that all ductwork <u>in any direction</u> be acoustically lined.

1. Ductwork downstream of terminal units a minimum distance of 10 feet.

2. Built-up casings and plenums, except that lining shall be 2" thick, and add inner metal liner.

3. All supply air ductwork a distance of 25 feet from fan discharge. If the distance from fan discharge to mechanical equipment room wall is more than 25 feet continue acoustical lining to the mechanical equipment room wall.

4. All conditioned air supply ductwork from roof top units to a distance of 25 feet from fan discharge. If the distance from fan discharge to roof or wall penetration is less than 25 feet, continue acoustic lining to a distance of 25 feet from fan discharge.

5. Upstream of return fans and exhaust fans, a minimum distance of 10 feet.

6. Upstream of outside air supply fans, a minimum of 15 feet.

7. Downstream from exhaust fans a minimum of 10 feet if the discharge of the exhaust fan runs through occupied spaces.

8. Where shown on drawings.

END OF SECTION 15260

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY REFER TO SCHEDULE ON DRAWINGS

A. This Section includes the following conventional plumbing fixtures and related components:

1. Faucets for lavatories, showers and sinks.
2. Laminar-flow faucet-spout outlets.
3. Flushometers.
4. Toilet seats.
5. Protective shielding guards.
6. Fixture supports.
7. Interceptors.
8. Shower receptors.
9. Disposers.
10. Drinking fountain.
11. Electric water cooler.
12. Water closets.
13. Urinals.
14. Lavatories.
15. Commercial sinks..
16. Individual showers.
17. Kitchen sinks.
18. Service sinks.
19. Mop receptor..
20. Owner-furnished fixtures.

B. Related Sections include the following:

1. Division 2 Section "Water Distribution" for exterior plumbing fixtures and hydrants.
2. Division 10 Section "Toilet and Bath Accessories."
3. Division 15 Section "Plumbing - Emergency Plumbing Fixtures."
4. Division 15 Section "Plumbing - Security Plumbing Fixtures."
5. Division 15 Section "Plumbing Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.

C. Cast Polymer: Cast-filled-polymer-plastic material. This material includes cultured-marble and solid-surface materials.

D. Cultured Marble: Cast-filled-polymer-plastic material with surface coating.

E. Drinking Fountain: Fixture with nozzle for delivering stream of water for drinking.

F. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.

G. Fixture: Plumbing unit connected to water and waste.

H. FRP: Fiberglass-reinforced plastic.

I. PMMA: Polymethyl methacrylate (acrylic) plastic.

J. PVC: Polyvinyl chloride plastic.

K. Remote Water Cooler: Electrically powered equipment for generating cooled drinking water.

L. Solid Surface: Nonporous, homogeneous, cast-polymer-plastic material with heat-, impact-, scratch-, and stain-resistance qualities.

M. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.4 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.

D. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.

1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act" and local code; for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

G. ARI Standard: Comply with ARI's "Directory of Certified Drinking Water Coolers: for style classifications.

H. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.

I. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

J. Comply with the following applicable standards and other requirements specified for plumbing fixtures:

1. Enameled, Cast-Iron Fixtures: ASME A112.19.1M.
2. Plastic Mop-Service Basins: ANSI Z124.6.
3. Plastic Shower Enclosures: ANSI Z124.2.
4. Slip-Resistant Bathing Surfaces: ASTM F 462.
5. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
6. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
7. Vitreous-China Fixtures: ASME A112.19.2M.
8. Water-Closet, Flush Valve, Trim: ASME A112.19.5.

K. Comply with the following applicable standards and other requirements specified for lavatory and/or sink faucets:

1. Backflow Protection Devices for Faucets with Hose-Thread Outlet: ASME A112.18.3M.
2. Faucets: ASME A112.18.1.
3. Hose-Connection Vacuum Breakers: ASSE 1011.
4. Hose-Coupling Threads: ASME B1.20.7.
5. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
6. NSF Potable-Water Materials: NSF 61.
7. Pipe Threads: ASME B1.20.1.
8. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
9. Supply Fittings: ASME A112.18.1.
10. Brass Waste Fittings: ASME A112.18.2.

L. Comply with the following applicable standards and other requirements specified for bathtub and/or shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald Faucets: ASSE 1016.
3. Faucets: ASME A112.18.1.
4. Hand-Held Showers: ASSE 1014.
5. High-Temperature-Limit Controls for Thermal-Shock-Preventing Devices: ASTM F 445.
6. Hose-Coupling Threads: ASME B1.20.7.
7. Manual-Control Antiscald Faucets: ASTM F 444.
8. Pipe Threads: ASME B1.20.1.
9. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
10. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
11. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.

M. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:

1. Atmospheric Vacuum Breakers: ASSE 1001.
2. Brass and Copper Supplies: ASME A112.18.1.
3. Manual-Operation Flushometers: ASSE 1037.
4. Plastic Tubular Fittings: ASTM F 409.
5. Brass Waste Fittings: ASME A112.18.2.
6. Sensor-Operation Flushometers: ASSE 1037 and UL 1951.

N. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Flexible Water Connectors: ASME A112.18.6.
2. Floor Drains: ASME A112.6.3.
3. Grab Bars: ASTM F 446.
4. Hose-Coupling Threads: ASME B1.20.7.
5. Off-Floor Fixture Supports: ASME A112.6.1M.
6. Pipe Threads: ASME B1.20.1.
7. Plastic Shower Receptors: ANSI Z124.2.
8. Plastic Toilet Seats: ANSI Z124.5.
9. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.6 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.1 LAVATORY FAUCETS

A. Lavatory Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Bradley Corporation.
c. Chicago Faucets.
d. Delta Faucet Company.
e. Eljer.
f. Elkay Manufacturing Co.
g. Fisher Manufacturing Co.
h. Grohe America, Inc.
i. Just Manufacturing Company.
j. Kohler Co.
k. Moen, Inc.
l. Royal Brass Mfg. Co.
m. Sayco; a Briggs Plumbing Products, Inc. Company.
n. Speakman Company.
o. T & S Brass and Bronze Works, Inc.
p. Zurn Plumbing Products Group; Commercial Brass Operation.

2. Description: Single-control mixing valve. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor, sensor operated with 0.5 GPM flow control.

2.2 SHOWER FAUCETS

A. Shower Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Delta Faucet Company.
   b. Hansgrohe Inc.
   c. Leonard Valve Company.
   d. Powers; a Watts Industries Co..
   e. Speakman Company.
   f. Symmons Industries, Inc.

2. Description: Single-handle thermostatic or thermostatic and pressure-balance valve. Include hot- and cold-water indicators; check stops; and shower head, arm, and flange. Coordinate faucet inlets with supplies and with 1.5 GPM flow control.

2.3 SINK FAUCETS

A. Sink Faucets:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Delta Faucet Company.
   b. Grohe America, Inc.
   c. Just Manufacturing Company.
   d. Kohler Co.
   e. Speakman Company.
   f. Symmons

2. Description: Kitchen faucet with spray, three-hole fixture or Kitchen faucet with spray, four-hole fixture or Kitchen faucet without spray or Laundry tray faucet or Service sink faucet with stops in shanks, vacuum breaker, hose-thread outlet, and pail hook or Bar sink faucet. Include hot- and cold-water indicators; coordinate faucet inlets with supplies and fixture holes; coordinate outlet with spout and fixture receptor with 1.5 GPM flow control

2.4 FLUSHOMETERS

A. Flushometers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Sloan Valve Company.
   b. Zurn Plumbing Products Group; Commercial Brass Operation.

c. Hydrotek International, Inc.
d. Sloan Valve Company.
e. TOTO USA, Inc.

2. Description: Flushometer for urinal and water-closet-type fixture. Include brass body with corrosion-resistant internal components, control stop with check valve, vacuum breaker, copper or brass tubing, and polished chrome-plated finish on exposed parts, sensor operated with 1.28 GPM for urinal.

2.5 TOILET SEATS

A. Toilet Seats:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Bemis Manufacturing Company.
c. Centoco Manufacturing Corp.
d. Church Seats.
e. Eljer.
f. Kohler Co.
g. Olsonite Corp.
h. Sanderson Plumbing Products, Inc.; Beneke Div.
i. Sperzel.

2.6 PROTECTIVE SHIELDING GUARDS

A. Protective Shielding Pipe Covers:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Engineered Brass Co.
b. Insul-Tect Products Co.; a Subsidiary of MVG Molded Products.
c. McGuire Manufacturing Co., Inc.
d. Plumberex Specialty Products Inc.
e. TCI Products.
f. TRUEBRO, Inc.
g. Zurn Plumbing Products Group; Tubular Brass Plumbing Products Operation.

3. Description: Manufactured plastic wraps for covering plumbing fixture hot- and cold-water supplies and trap and drain piping. Comply with Americans with Disabilities Act (ADA) requirements.

2.7 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Water-Closet Supports:

1. Description: Combination carrier designed for accessible or standard mounting height of wall-mounting, water-closet-type fixture. Include single or double, vertical or horizontal, hub-and-spigot or hubless waste fitting as required for piping arrangement; faceplates; couplings with gaskets; feet; and fixture bolts and hardware matching fixture. Include additional extension coupling, faceplate, and feet for installation in wide pipe space.

C. Urinal Supports:

1. Description: Urinal carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture for wall-mounting, urinal-type fixture. Include steel uprights with feet.

2. Accessible-Fixture Support: Include rectangular steel uprights.

D. Lavatory Supports:

1. Description: Lavatory carrier with exposed arms and tie rods, lavatory carrier with concealed arms and tie rod for wall-mounting, lavatory-type fixture. Include steel uprights with feet.

2. Accessible-Fixture Support: Include rectangular steel uprights.

E. Sink Supports:

1. Description: Sink carrier with exposed arms and tie rods for sink-type fixture. Include steel uprights with feet.

2.8 INTERCEPTORS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Josam Company.
2. MIFAB Manufacturing Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.

B. Sediment Interceptors:

1. Description: Manufactured unit with removable screens or strainer and removable cover; designed to trap and retain waste material.

   a. Material: Cast-iron or steel body with acid-resistant lining and coating or carbon-steel body with acid-resistant lining and coating or stainless-steel.
   b. Pipe Connections: 6".

2.9 SHOWER RECEPTORS

A. Shower Receptors:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. Crane Plumbing, L.L.C./Fiat Products.
   b. Florestone Products Co., Inc.
   c. Aker Plastics Co., Inc.
   d. LASCO Bathware.
   e. Mustee, E. L. & Sons, Inc.
   f. Sterling Plumbing Group, Inc.
   g. Swan Corporation (The).

2. Description: Cast-polymer or FRP or PMMA or Precast-terrazzo or Solid-surface base for built-up-type shower fixture.

   a. Type: Standard or residential or Handicapped/wheelchair.
   b. Size: [**32 by 32 inches (813 by 813 mm)**] [**36 by 36 inches (914 by 914 mm)**] [**32 by 42 inches (813 by 1067 mm)**] [**48 by 60 inches (1219 by 1524 mm)**].
   c. Color: White.
   d. Outlet: Cast-in-floor drain or Drain with NPS 1-1/2 (DN 40) or NPS 2 (DN 50) or NPS 3 (DN 80) outlet.

2.10 DRINKING FOUNTAINS

A. Exterior Drinking Fountains:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Filtrine Manufacturing Company; Drinking Water Division.
   b. Halsey Taylor.
   c. Haws Corporation.
   d. Most Dependable Fountains, Inc.
   e. Murdock, Inc.
   f. Oasis Corporation.
   g. Stern-Williams Co., Inc.
   h. Sunroc Corp.

B. Interior Drinking Fountains, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkay Manufacturing Co.
   b. Filtrine Manufacturing Company; Drinking Water Division.
   c. Halsey Taylor.
   d. Haws Corporation.
   e. Murdock, inc.
   f. Oasis Corporation.
   g. Stern-Williams Co., Inc.
   h. Sunroc Corp.
   i. Elkay Manufacturing Co.
   j. Filtrine Manufacturing Company; Drinking Water Division.
   k. Halsey Taylor.
   l. Haws Corporation.
   m. Stern-Williams Co., Inc.
   n. Sunroc Corp.
   o. American Standard, Inc.
   p. Crane Plumbing, L.L.C./Fiat Products.
   q. Eljer.
   r. Kohler Co.
   s. Sunroc Corp.

C. Interior Drinking Fountains, Semi-Recessed:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Elkay Manufacturing Co.
   b. Filtrine Manufacturing Company; Drinking Water Division.
   c. Halsey Taylor.
   d. Haws Corporation.
   e. Oasis Corporation.
   f. Sunroc Corp.
   g. Crane Plumbing, L.L.C./Fiat Products.
   h. Kohler Co.

D. Interior Drinking Fountains, Recessed:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:
   a. Elkay Manufacturing Co.
   b. Filtrine Manufacturing Company; Drinking Water Division.
   c. Halsey Taylor.
   d. Haws Corporation.
   e. Oasis Corporation.
   f. Sunroc Corp.

E. Water Coolers, Recessed:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide a comparable product by one of the following:

   a. Elkay Manufacturing Co.
   b. Halsey Taylor.
   c. Haws Corporation.
   d. Oasis Corporation.
   e. Sunroc Corp.

2.11 FIXTURE SUPPORTS

A. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of hte following:

1. Josam Co.
2. MIFAB Manufacturing, Inc.
3. Smith, Jay R. Mfg. Co.
4. Tyler Pipe; Wade Div.
5. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
6. Zurn Plumbing Products Group; Specification Drainage Operation.

2.12 WATER CLOSETS

A. Water Closets:

1. Low flow type WC 1.28 GPF with touchless control.

2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Crane Plumbing, L.L.C./Fiat Products.
   b. American Standard Companies, Inc.
   c. American Standard Companies, Inc.
   d. Briggs Plumbing Products, Inc.
   e. Capizzi.
   f. Eljer.
   g. Kohler Co.
   h. St. Thomas Creations.
   i. TOTO USA, Inc.URINALS

B. Urinals:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Briggs Plumbing Products, Inc.
c. Capizzi.
d. Crane Plumbing, L.L.C./Fiat Products.
e. Duravit USA, Inc.
f. Eljer.
g. Kohler Co.
h. Mansfield Plumbing Products, Inc.
i. Peerless Pottery, Inc.
j. Sanitarios Azteca, S.A. de C.V.
k. St. Thomas Creations.
l. TOTO USA, Inc.

2.13 LAVATORIES

A. Lavatories:

1. Low flow type LAV 0.5 GPM with touchless control. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Commercial Enameling Company.
c. Eljer.
d. Kohler Co.
e. Barclay Products, Ltd.
f. Briggs Plumbing Products, Inc.
g. Crane Plumbing, L.L.C./Fiat Products.
h. Gerber Plumbing Fixtures LLC.
i. Mansfield Plumbing Products, Inc.
j. Peerless Pottery, Inc.
k. Sterling Plumbing Group, Inc.
l. St. Thomas Creations.
m. TOTO USA, Inc.

2.14 COMMERCIAL SINKS - STAINLESS STEEL

A. Commercial Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Advance Tabco.
b. Elkay Manufacturing Co.
c. Just Manufacturing Company.
d. Metal Masters Foodservice Equipment Co., Inc.

2.15 INDIVIDUAL SHOWERS

A. Individual Showers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Aker Plastics Co., Inc.
   b. Aqua Glass Corporation.
   c. Clarion Bathware.
   d. Florestone Products Co., Inc.
   e. LASCO Bathware.
   f. Praxis Industries, Inc.; Aquarius Products.
   g. Sterling Plumbing Group, Inc.
   h. Swan Corporation (The).
   i. Acryline USA, Inc.
   j. Aqua Bath Company, Inc.
   k. Aquatic Industries, Inc.
   l. Crane Plumbing, L.L.C./Fiat Products.
   m. Jacuzzi, Inc.
   n. Kohler Co.
   o. Praxis Industries, Inc.; Aquarius Products.

2.16 KITCHEN SINKS

A. Kitchen Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Commercial Enameling Company.
   b. Eljer.
   c. Jacuzzi, Inc.
   d. Kohler Co.
   e. Gerber Plumbing Fixtures LLC.
   f. Lyons Industries, Inc.
   g. American Standard Companies, Inc.
   h. Bootz Plumbingware Co.
   i. Briggs Plumbing Products, Inc.
   j. Mansfield Plumbing Products, Inc.
   k. Avonite, Inc.
   l. DuPont, Corian Products.
   m. FHP Kindred USA.
   n. Formica Corporation.
   o. Franke Consumer Products, Inc., Kitchen Systems Div.
   p. Lippert Corporation.
   q. Rynone Manufacturing Corp.
   r. Swan Corporation (The).
   s. Wilsonart International.

t. Dayton Products, Inc.
u. Elkay Manufacturing Co.
v. Just Manufacturing Company.
w. Moen, Inc.
x. Revere Sink.
y. Sterling Plumbing Group, Inc.
z. Teka USA.
aa. WhiteRock Corp.

B. Bar Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Commercial Enameling Company.
b. Eljer.
c. Jacuzzi, Inc.
d. Kohler Co.
e. Benjamin Manufacturing Co., Inc.
f. Gerber Plumbing Fixtures LLC.
g. Lippert Corporation.
h. Lyons Industries, Inc.
i. Royal Baths Manufacturing Co.
j. American Standard Companies, Inc.
k. Bootz Plumbingware Co.
l. Briggs Plumbing Products, Inc.
m. Mansfield Plumbing Products, Inc.
n. Avonite, Inc.
o. DuPont, Corian Products.
p. Formica Corporation.
q. Swan Corporation (The).
r. Barclay Products, Ltd.
s. Dayton Products, Inc.
t. Elkay Manufacturing Co.
u. Franke Consumer Products, Inc.; Kitchen Systems Div.

2.17 SERVICE SINKS

A. Service Sinks:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. American Standard Companies, Inc.
b. Commercial Enameling Company.
c. Crane Plumbing, L.L.C./Fiat Products.
d. Eljer.
e. Kohler Co.

2.18 MOP RECEPTOR

A. Mop Receptor:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Acorn Engineering Company.
   b. Crane Plumbing, L.L.C./Fiat Products.
   c. Florestone Products Co., Inc.
   d. Precast Terrazzo Enterprises, Inc.
   e. Stern-Williams Co., Inc.
   f. Mustee, E. L. & Sons, Inc.
   g. Swan Corporation (The).
   h. Zurn Plumbing Products Group; Light Commercial Operation.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.

B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.

   1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
   2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
   3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
   4. Use mounting frames fr recessed water coolers, unless otherwise indicated.

C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.

D. Install wall-mounting fixtures with tubular waste piping attached to supports.

E. Install counter-mounting fixtures in and attached to casework.

F. Install fixtures level and plumb according to roughing-in drawings.

G. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.

1. Exception: Use ball, gate, or globe valves if supply stops are not specified with fixture. Valves are specified in Division 15 Section "Valves."

H. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.

I. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.

J. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.

K. Install toilet seats on water closets.

L. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

M. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.

N. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

O. Install shower flow-control fittings with specified maximum flow rates in shower arms.

P. Install traps on fixture outlets.

1. Exception: Omit trap on fixtures with integral traps.
2. Exception: Omit trap on indirect wastes, unless otherwise indicated.

Q. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 15 Section "Basic Mechanical Materials and Methods."

R. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 7 Section "Joint Sealants."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Verify that installed plumbing fixtures are categories and types specified for locations where installed.

B. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.

C. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.

D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

E. Install fresh batteries in sensor-operated mechanisms.

F. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.

1. Remove and replace malfunctioning units and retest as specified above.
2. Report test results in writing.

3.5 ADJUSTING

A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.

B. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.

C. Replace washers and seals of leaking and dripping faucets and stops.

D. Install fresh batteries in sensor-operated mechanisms.

E. Adjust drinking fountain/water cooler fixture flow regulators for proper flow and stream height.

F. Adjust water cooler temperature settings.

3.6 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.

2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

C. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

3.7 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15410

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following emergency plumbing fixtures:

1. Emergency showers.
2. Eyewash equipment.
3. Eye/face wash equipment.
4. Combination units.
5. Water-tempering equipment.

B. Related Sections include the following:

1. Division 15 Section "Plumbing Specialties" for backflow preventers and floor drains.
2. Division 15 Section "Plumbing - Water Filtration Equipment" for water filters.

1.3 DEFINITIONS

A. Accessible Fixture: Emergency plumbing fixture that can be approached, entered, and used by people with disabilities.

B. Plumbed Emergency Plumbing Fixture: Fixture with fixed, potable-water supply.

C. Self-Contained Emergency Plumbing Fixture: Fixture with flushing-fluid-solution supply.

D. Tepid: Moderately warm.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include flow rates and capacities, furnished specialties, and accessories.

B.
Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: Submit certificates of performance testing specified in "Source Quality Control" Article.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For emergency plumbing fixtures to include in maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ANSI Standard: Comply with ANSI Z358.1, "Emergency Eyewash and Shower Equipment."

C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act;" or local code for plumbing fixtures for people with disabilities.

D. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushing-Fluid Solution: Separate lot and equal to at least [**200**] <**Insert number**> percent of amount of solution installed for each self-contained unit.

PART 2 - PRODUCTS

2.1 EMERGENCY SHOWERS - SEE SCHEDULE ON DRAWINGS

A. Emergency Showers, Single Shower Head:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bradley Corporation.
b. Chicago Faucets.
c. Encon Safety Products.
d. Guardian Equipment Co.
e. Haws Corporation.
f. Lab Safety Supply Inc.

g. Murdock, Inc.
h. Sellstrom Manufacturing Co.
i. Speakman Company.
j. WaterSaver Faucet Co.
k. Western Emergency Equipment.

2. Description: Plumbed, single-shower-head horizontal, wall-mounting or vertical, ceiling-mounting or freestanding emergency shower.

a. Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1 (DN 25), NPS 1-1/4 (DN 32), galvanized steel, chrome-plated brass or stainless steel, PVC with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Pull rod, chain.
d. Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel, plastic.

2.2 EYEWASH EQUIPMENT

A. Eyewash Equipment, Free Standing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bradley Corporation.
b. Chicago Faucets.
c. Encon Safety Products.
d. Guardian Equipment Co.
e. Haws Corporation.
f. Lab Safety Supply Inc.
g. Murdock, Inc.
h. Sellstrom Manufacturing Co.
i. Speakman Company.
j. WaterSaver Faucet Co.
k. Western Emergency Equipment.

2. Description: Plumbed, freestanding eyewash equipment.

a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle, Push bar, Treadle.
d. Receptor: Chrome-plated brass or stainless-steel, Plastic bowl.
e. Drain Piping: [NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2, Omit drain piping, Include galvanized-steel indirect connection to drainage system.

B. Eyewash Equipment, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bradley Corporation.
   b. Chicago Faucets.
   c. Encon Safety Products.
   d. Guardian Equipment Co.
   e. Haws Corporation.
   f. Lab Safety Supply Inc.
   g. Sellstrom Manufacturing Co.
   h. Speakman Company.
   i. WaterSaver Faucet Co.
   j. Western Emergency Equipment.

2. Description: Plumbed, [**accessible,**]wall-mounting eyewash equipment with receptor and wall bracket.

   a. Capacity: Deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle.
   d. Receptor: Chrome-plated brass or stainless-steel, Plastic bowl.
   e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.

2.3 EYE/FACE WASH EQUIPMENT

A. Eye/Face Wash Equipment, Free Standing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bradley Corporation.
   b. Encon Safety Products.
   c. Guardian Equipment Co.
   d. Haws Corporation.
   e. Lab Safety Supply Inc.
   f. Murdock, Inc.
   g. Sellstrom Manufacturing Co.
   h. Speakman Company.
   i. WaterSaver Faucet Co.
   j. Western Emergency Equipment.

2. Description: Plumbed, freestanding, pedestal eye/face wash equipment.

   a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
   b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
   c. Control-Valve Actuator: Paddle, Push bar, Treadle.
   d. Receptor: Chrome-plated brass or stainless-steel, Plastic bowl.

e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.Include galvanized-steel indirect connection to drainage system.

B. Eye/Face Wash Equipment, Wall Mounted:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bradley Corporation.
b. Chicago Faucets.
c. Encon Safety Products.
d. Guardian Equipment Co.
e. Haws Corporation.
f. Lab Safety Supply Inc.
g. Sellstrom Manufacturing Co.
h. Speakman Company.
i. WaterSaver Faucet Co.
j. Western Emergency Equipment.

2. Description: Plumbed, [**accessible,**]wall-mounting eye/face wash equipment with receptor and wall bracket.

a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.
d. Receptor: Chrome-plated brass or stainless-steel, Plastic bowl.
e. Drain Piping: NPS 1-1/4 (DN 32) minimum, chrome-plated brass, receptor drain, P-trap, waste to wall, and wall flange complying with ASME A112.18.2.

C. Eye/Face Wash Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Bradley Corporation.
b. Encon Safety Products.
c. Guardian Equipment Co.
d. Haws Corporation.
e. WaterSaver Faucet Co.

2. Description: Plumbed, accessible, wall-mounting eye/face wash equipment without receptor and with wall bracket.

a. Capacity: Deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.
b. Supply Piping: NPS 1/2 (DN 15) chrome-plated brass or stainless steel with flow regulator and stay-open control valve.
c. Control-Valve Actuator: Paddle.

2.4 COMBINATION UNITS

A. Combination Units, Free Standing:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Bradley Corporation.
   b. Chicago Faucets.
   c. Encon Safety Products.
   d. Guardian Equipment Co.
   e. Haws Corporation.
   f. Lab Safety Supply Inc.
   g. Murdock, Inc.
   h. Sellstrom Manufacturing Co.
   i. Speakman Company.
   j. WaterSaver Faucet Co.
   k. Western Emergency Equipment.

2. Description: Plumbed, accessible, freestanding, with emergency shower and eyewash, eye/face wash, drench hose equipment.

   a. Piping: Galvanized steel, Chrome-plated brass or stainless steel, PVC.

      1) Unit Supply: NPS 1-1/4 (DN 32) minimum, NPS 1-1/2 (DN 40) from top, side.
      2) Unit Drain: Outlet at side near bottom.
      3) Shower Supply: NPS 1 (DN 25) with flow regulator and stay-open control valve.
      4) Eyewash, Eye/Face Wash, Drench Hose Supply: NPS 1/2 (DN 15) with flow regulator and stay-open control valve.

   b. Shower Capacity: Deliver potable water at rate not less than 20 gpm (76 L/min.) for at least 15 minutes.

      1) Control-Valve Actuator: Pull rod, Pull chain, Treadle.
      2) Shower Head: 8-inch (200-mm) minimum diameter, chrome-plated brass or stainless steel, plastic.

   c. Eyewash Equipment: With capacity to deliver potable water at rate not less than 0.4 gpm (1.5 L/min.) for at least 15 minutes.

      1) Control-Valve Actuator: Paddle, Push bar.
      2) Receptor: Chrome-plated brass or stainless-steel, Plastic bowl.

   d. Eye/Face Wash Equipment: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.

      1) Control-Valve Actuator: Paddle, Push bar.
      2) Receptor: Chrome-plated brass or stainless-steel, Plastic bowl.

   e. Hand-Held Drench Hose: With capacity to deliver potable water at rate not less than 3.0 gpm (11.4 L/min.) for at least 15 minutes.

1) Hose: Rubber or plastic.
2) Control-Valve Actuator: Hand-held squeeze valve.
3) Spray Head(s): Single, Twin.

2.5 WATER-TEMPERING EQUIPMENT

A. Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Armstrong International, Inc.
   b. Bradley Corporation.
   c. Encon Safety Products.
   d. Haws Corporation.
   e. Lawler Manufacturing Co., Inc.
   f. Leonard Valve Company.
   g. Powers, a Watts Industries Co.
   h. Speakman Company.
   i. Therm-Omega-Tech, Inc.
   j. Western Emergency Equipment.

2. Description: Factory-fabricated, hot- and cold-water-tempering equipment with thermostatic mixing valve.

   a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, metal piping, and corrosion-resistant enclosure.

B. Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Encon Safety Products.
   b. Therm-Omega-Tech, Inc.

2. Description: Factory-fabricated, steam and cold-water, water-tempering equipment with thermostatic mixing valve.

   a. Thermostatic Mixing Valve: Designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, steam controls, heat exchanger, high-temperature-limit and freeze-protection devices, metal piping, and corrosion-resistant enclosure.

C. Water-Tempering Equipment:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Chronomite Laboratories, Inc.

2. Description: Factory-fabricated, water-tempering equipment with electric heating.

   a. Heating System: Electric, designed to provide 85 deg F (29 deg C) tepid, potable water at emergency plumbing fixtures, to maintain temperature at plus or minus 5 deg F (3 deg C) throughout required 15-minute test period, and in case of unit failure to continue cold-water flow, with union connections, controls, heating coils, high-temperature-limit device, metal piping, and corrosion-resistant enclosure.

      1) Electrical Characteristics: [208-V ac, 38] [220-V ac, 40] [277-V ac, 32] A, single phase, 60 Hz.

2.6 SOURCE QUALITY CONTROL

A. Certify performance of plumbed and/or self-contained emergency plumbing fixtures by independent testing agency acceptable to authorities having jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before plumbed emergency plumbing fixture installation.

   1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 EMERGENCY PLUMBING FIXTURE INSTALLATION

A. Assemble emergency plumbing fixture piping, fittings, control valves, and other components.

B. Install fixtures level and plumb.

C. Fasten fixtures to substrate.

D. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves chained or locked in open position if permitted. Install valves in locations where they can easily be reached for operation. Valves are specified in Division 15 Section "Plumbing - Valves."

   1. Exception: Omit shutoff valve on supply to group of plumbing fixtures that includes emergency plumbing fixture.
   2. Exception: Omit shutoff valve on supply to emergency equipment if prohibited by authorities having jurisdiction.

E. Install shutoff valve and strainer in steam piping and shutoff valve in condensate return piping.

F. Install dielectric fitting in supply piping to fixture if piping and fixture connections are made of different metals. Dielectric fittings are specified in Division 15 Section "Basic Plumbing Materials and Methods."

G. Install thermometers in supply and outlet piping connections to water-tempering equipment. Thermometers are specified in Division 15 Section "Plumbing - Meters and Gages."

H. Install trap and waste to wall on drain outlet of fixture receptors that are indicated to be directly connected to drainage system.

I. Install indirect waste piping to wall on drain outlet of fixture receptors that are indicated to be indirectly connected to drainage system. Drainage piping is specified in Division 15 Section "Sanitary Waste and Vent Piping."

J. Install escutcheons on piping wall and ceiling penetrations in exposed, finished locations. Escutcheons are specified in Division 15 Section "Basic Plumbing Materials and Methods."

K. Fill self-contained fixtures with flushing fluid.

L. Install equipment nameplates or equipment markers on fixtures and equipment signs on water-tempering equipment. Identification materials are specified in Division 15 Section "Mechanical Identification."

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect cold-water-supply piping to plumbed emergency plumbing fixtures not having water-tempering equipment.

C. Connect hot- and cold-water-supply piping to hot- and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.

D. Connect cold-water and steam supply and condensate return piping to steam and cold-water-tempering equipment. Connect output from water-tempering equipment to emergency plumbing fixtures.

E. Connect cold water and electrical power to electric heating water-tempering equipment.

F. Directly connect emergency plumbing fixture receptors with trapped drain outlet to sanitary drainage and vent piping.

G. Indirectly connect emergency plumbing fixture receptors without trapped drain outlet to sanitary or storm drainage piping.

H. Ground equipment according to Division 16 Section "Grounding and Bonding."

I. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Mechanical-Component Testing: After plumbing connections have been made, test for compliance with requirements. Verify ability to achieve indicated capacities and temperatures.

B. Electrical-Component Testing: After electrical circuitry has been energized, test for compliance with requirements.

1. Test and adjust controls and safeties.

C. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

D. Report test results in writing.

3.5 ADJUSTING

A. Adjust or replace fixture flow regulators for proper flow.

B. Adjust equipment temperature settings.

END OF SECTION 15412

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following security plumbing fixtures and related components:

1. Combination units.

B. Related Sections include the following:

1. Division 10 Section "Toilet and Bath Accessories."
2. Division 15 Section "Plumbing Fixtures."
3. Division 15 Section "Plumbing - Emergency Fixtures."

1.3 DEFINITIONS

A. Accessible Fixture: Security plumbing fixture that can be approached and used by people with disabilities.

B. Back-Mounting-Type Fixture: Security plumbing fixture designed to mount on wall sleeve built into wall so installation and removal of fixture and piping and other components are only accessible from service space behind wall.

C. Front-Mounting-Type Fixture: Security plumbing fixture designed to mount on fixture support with installation and removal from fixture side of wall, and piping and other components are accessible from access panels in fixture or wall.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include furnished specialties and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For security plumbing fixtures to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"**; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act;" or local code** about security plumbing fixtures for people with disabilities.

C. NSF Standard: Comply with NSF 61, "Drinking Water System Components - Health Effects," for fixture materials that will be in contact with potable water.

D. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

1.6 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Flushometer Valves: Equal to 10 percent of amount installed for each type indicated, but no fewer than 2 units.
2. Mechanical and Air-Operated Valves: Equal to 10 percent of amount installed for each type indicated, but no fewer than 2 units.

PART 2 - PRODUCTS

2.1 COMBINATION UNITS - SEE SCHEDULE ON DRAWINGS

A. Security Combination Units:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

a. Acorn Engineering Company.
b. Bradley Corporation.
c. Metcraft Industries Inc.
d. Willoughby Industries, Inc.

2. Description: Back-mounting, cabinet, security plumbing fixture with integral water closet and lavatory; fabricated from [**0.078-inch (2.0-mm) minimum**] [**0.109-inch (2.8-mm)**] thickness, ASTM A 666, Type 304 stainless steel. Include SSINA No. 4 polished finish on exposed surfaces, and corrosion-resistant metal for internal piping and bracing.

a. Water Closet: Comply with IAPMO PS 61 for water-closet component.

1) Bowl: Elongated, with back inlet, integral trap, [**blowout design with back**] [**siphon-jet design with back**] [**siphon-jet design with floor**] outlet and contoured seat.

a) Seat Surface: SSINA No. 7 polished finish.
b) Punching: Provide two holes for installation of separate toilet seat.
c) Drain: [**NPS 4 (DN 100)**] [**NPS 3 (DN 80)**], [**horizontal with cleanout and slip joint**] [**vertical**].

2) Flushing Device: Concealed flushometer valve with stainless-steel access panel, push-button mechanism, and [**3.5-gal./flush (13.3-L/flush)**] [**1.6-gal./flush (6.0-L/flush)**] <**Insert value**> consumption. Refer to "Flushometer Valves" Article.

b. Lavatory: In top of cabinet.

1) Receptor: [**Oval**] [**or**] [**rectangular**] bowl with integral soap depression.
2) Hot- and Cold-Water[**and Bubbler**] Supply Valves: [**Pneumatic**] [**Mechanical-metering**] [**Electric-solenoid**] type with push-button actuation and individual check stop.
3) Filler Spout: [**Backsplash or deck**] [**Backsplash**] [**Deck**] mounted.
4) Drain: Integral punched grid with [**NPS 1-1/4 (DN 32) minimum horizontal waste and trap complying with ASME A112.18.2**] [**concealed waste piping to spill into water-closet bowl**].
5) Toothbrush Holders: One on [**each**] [**left**] [**right**] side of backsplash.
6) Towel Hooks: [**One**] [**Two**] on [**each**] [**left**] [**right**] side of fixture.
7) Bubbler Location: On [**backsplash**] [**deck**].

c. Cabinet Configuration: [**Rectangular apron**] [**Five-sided apron with two angled sides**] [**Four-sided apron with angled left side**] [**Four-sided apron with angled right side**] <**Insert configuration**>, made for [**above**] [**on**]-floor installation and with backsplash.

1) Water-Closet Bowl Location: [**Centered on front**] [**Left of center on front**] [**Right of center on front**] [**On angled left side**] [**On angled right side**] <**Insert location**> of apron.
2) Toilet Paper Holder: Recessed, 0.063-inch (1.6-mm) minimum thickness, stainless steel complying with ASTM A 666, Type 304 and located [**above water closet and centered in front**] [**in front**] [**right of center in front**] [**left of center in front**] [**in angled right side**] [**in angled left side**] [**in right side**] [**in left side**] <**Insert location**> of apron.

d. Wall Sleeve: Galvanized-steel frame of dimensions required to match and support entire fixture. Include steel bars or other design that will prevent escape if fixture is removed.

2.2 FIXTURE SUPPORTS

A. Off-Floor, Plumbing Fixture Supports:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

   a. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe; Wade Div.
   e. Watts Drainage Products Inc.; a div. of Watts Industries, Inc.
   f. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Description: ASME A112.6.1M carriers with dimensions and trim matching fixture.

   a. Stainless-Steel, Front-Mounting Fixtures: With modifications.

      1) Drinking Fountains: Type I drinking fountain carrier.
      2) Lavatories: Type III lavatory carrier.
      3) Shampoo Bowls: Type II sink carrier.
      4) Urinals: Type I urinal carrier with inlet seal unless Type II is required.
      5) Water Closets: Combination support and waste fitting assembly.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in for water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before security plumbing fixture installation.

B. Examine floors and walls for suitable conditions where security plumbing fixtures will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 SECURITY PLUMBING FIXTURE INSTALLATION

A. Install back-mounting-type, stainless-steel security plumbing fixtures as follows:

1. Install wall sleeve in wall.
2. Install fixture on wall sleeve; mount components on or attached to wall sleeve with access from accessible service space.
3. Extend supply piping from service space to fixture.
4. Install soil and waste piping from fixture and extend into service space.
5. Install fixture trap in service space instead of below fixture drain.

B. Install front-mounting-type, stainless-steel security plumbing fixtures as follows:

1. Install fixture support or mounting bracket.
2. Install fixture on support; mount components inside of or attached to fixture.
3. Extend supply piping from pipe space to fixture.
4. Install trap below fixture and extend soil and waste piping into pipe space.

C. Install security plumbing fixture outlets with gasket seals.

D. Install fixtures designated "accessible" according to ICC A117.1 for heights, dimensions, and clearances.

E. Install fixtures level and plumb.

F. Install shutoff valves in water-supply piping to fixtures. Use ball, gate, or globe valve if specific type valve is not indicated. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 15 Section "Valves."

G. Install dielectric fittings in water-supply piping to fixtures if piping and fixture connections are made of different metals. See Division 15 Section "Basic Mechanical Materials and Methods" for dielectric fittings.

H. Install toilet seats on **combination units** if seats are indicated.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect hot- and cold-water supply piping to security plumbing fixtures. Include supply stops, if specified, or ball valve on each supply. Ball valves are specified in Division 15 Section "Plumbing - Valves."

C. Connect soil and waste piping to security plumbing fixtures.

D. Ground equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Testing: After installing security plumbing fixtures **and after electrical circuitry has been energized**, test for compliance with requirements.
2. Remove and replace malfunctioning security plumbing fixtures. Retest as specified above after repairs or replacements are made.

3.5 ADJUSTING

A. Operate and adjust water-supply flushometers and flow-control valves on security plumbing fixtures.

3.6 CLEANING

A. Clean security plumbing fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall spouts and strainers.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.7 PROTECTION

A. Provide protective covering for installed security plumbing fixtures and fittings.

B. Do not allow use of security plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 15413

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Spring hangers.

B. Related Work:

1. Section 15450 - Basic (Plumbing) Materials, Methods and Requirements.
2. Section 15410 - Piping and Fitting Materials.
3. Section 15415 - Domestic Water Heaters.
4. Section 15440 - Pumps.

1.3 DEFINITIONS

A. Effective peak velocity related acceleration coefficient.

B. OSHPD: Office of Statewide Health Planning & Development for the State of California. OSHPD assigns a unique anchorage preapproval "R" number to each seismic restraint it tests. The number describes a specific device applied as tested.

1.4 SUBMITTALS

A. Product Data: Include load deflection curves for each vibration isolation device.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Include the following:

1. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

2. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.

3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

4. Seismic-Restraint Details: Detail fabrication and attachment of seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

5. Submittals for Interlocking Snubbers: Include load deflection curves up to 1/2-inch (13-mm) deflection in x, y, and z planes.

C. Welding certificates.

D. Air-Mounting System Performance Certification: Include natural frequency, load, and damping tests performed by an independent laboratory or acoustician.

E. Manufacturer Seismic Qualification Certification: Submit certification that all specified equipment will withstand seismic forces identified in "Performance Requirements" Article above. Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.

(a) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

(b) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 QUALITY ASSURANCE

A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage preapproval "R" number, from OSHPD or another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not

available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.

B. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code-Steel."

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into base. Concrete, reinforcement, and formwork requirements are specified in Division 3.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Seismic Snubber Units: Furnish replacement neoprene inserts for all snubbers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.2 MOUNTING OF CENTRIFUGAL PUMPS - LOCATED ON SLAB ON GRADE (SLAB BEARING ON EARTH)

A. Each pump with its driving motor bolted and grouted to a minimum 10" thick concrete inertia base reinforced as required and isolation mounting pads between inertia base and concrete housekeeping pad.

B. Each concrete base (rectangular or "T" shape for horizontally split pumps) shall include supports and base elbows for the discharge and suction connections. Base elbows shall be bolted and grouted to the concrete foundation. **[The base shall incorporate seismic restrictions]**.

C. Isolation mounting pads of laminated cork and neoprene. Load distributing steel top plates provided where pump base does not provide uniform load surface.

2.3 MOUNTING OF CENTRIFUGAL PUMPS (GREATER THAN 3 HP) ON ABOVE GRADE FLOORS (SLAB NOT BEARING ON EARTH)

A. Each pump with its driving motor bolted and grouted to spring supported concrete inertia base reinforced as required.

B. Each concrete base (rectangular or "T" shape for horizontally split pumps) shall include supports and base elbows for the discharge and suction connections. Base elbows shall be bolted and grouted to the concrete foundation. **[The base shall incorporate seismic restraints].**

C. The spring supported concrete inertia foundation shall be poured within structural perimeter frame (reinforced as necessary) of the required thickness indicated in the above schedule. The structural perimeter frame **[complete with seismic restraints]** shall be equipped with height saving brackets and stable bare spring isolators having spring diameters no less than 0.8 of the compressed height of the spring at rated load.

D. The mountings shall provide minimum static deflections as recommended by manufacturer. The structural perimeter frame, mounting templates, saving brackets and spring system shall be provided as an assembly by the vibration control vendor.

2.4 MOUNTING OF CENTRIFUGAL PUMPS (3 HP OR LESS) ON ABOVE GRADE FLOORS (SLAB NOT BEARING ON EARTH)

A. Pumps 3 HP or less shall be bolted and grouted on rubber-in-shear supported reinforced concrete inertia blocks that are a minimum of 6" thick. Rubber-in-shear isolators shall provide a minimum static deflection of l-3/8" and shall be protected against corrosion. Mountings shall be:

2.5 MOUNTING OF PREFABRICATED WATER BOOSTER PUMP SYSTEMS:

A. Prefabricated, packaged (prepiped) pump equipment with vibration isolation mountings to set on a 4" high concrete housekeeping pads.

2.6 VERTICAL WATER HEATERS

A. Floor mounted on pipe stand or angle iron frame stand, welded construction, equipped with steel bearing floor plates.

2.7 GRAVITY HOUSE TANKS, SUCTION TANKS AND RETENTION TANKS MOUNTING

A. Supported on dunnage beams - refer to tanks specification section for details.

2.8 SUPPORT OF PIPING IN AND ADJACENT TO EQUIPMENT ROOMS

A. Support on dunnage beams - refer to tanks specification section for details.

2.9 SUPPORT OF PIPING IN AND ADJACENT TO EQUIPMENT ROOMS:

A. The following water piping shall be resiliently supported:

1. All piping in equipment room.

2. Piping outside of equipment rooms within 50 feet of connected rotating equipment.

3. **All other piping as described under Hangers Supports and Guides (Seismic Design) shall be rigidly supported and provided with approved seismic restraints to maintain the piping in a captive attitude without excessive motion. All piping conforming to the hanger rod spacing schedule as hereinbefore specified or as required to limit transmitted forces to the building structure to acceptable limits.**

B. Resilient diagonal mounting or other approved devices shall be provided as required to limit piping motion due to equipment startup or shutdown, to a maximum of 1/8".

C. Water piping hanger rod isolators shall contain a steel spring in series with a 1/4" acoustical neoprene pad with a steel box retainer. The hanger rod isolator assembly shall be rigidly supported one end from the building structure. The installed hanger rod supported from the spring sub-assembly shall not contact the steel box retainer and clearances in the isolator design shall be capable of accepting a 15 degree misalignment in any direction from the vertical.

D. The steel spring element of the assembly shall be designed to have a minimum surge frequency of 340 HZ and a minimum deflection of 3/4".

E. Where supplementary steel is required to support piping, the supplementary steel shall be sized so that maximum deflection between supports does not exceed 0.08" and shall be resiliently supported from the building structure with mountings as described above. Supported piping from the supplementary steel shall be rigidly suspended or supported.

F. Where isolated water piping 8" and larger is supported directly below exposed steel beams, attachment to the beam shall be made by means of welded channel beam located directly under the web of the beam. For piping 6" and smaller, beam clamps may be used in lieu of welding subject to approval of the beam clamp selection.

2.10 PIPING RISERS, ANCHORS, GUIDES, PUMP LINES:

A. Pipe risers with guides, anchors and supports, pump discharge lines (horizontal and vertical), shall be isolated from the building structure, such that there shall be no direct contact of the piping and supports with the building structure. Provide isolation pads with load bearing steel plates and supports with isolation material.

2.11 PIPING PENETRATIONS OF BUILDING SHAFTS, FLOOR SLABS, WALLS, PARTITIONS, ETC:

A. There shall be no direct contact of piping with shaft walls, floor slabs and/or partition. All voids around uninsulated piping shall be packed with caulking the full depth of the penetration.

B. Test equipment in service and demonstrate that the equipment performs the work intended for it and that it complies with the requirement of these specifications for such equipment.

2.12 RIGIDLY SUPPORTED EQUIPMENT:

A. All rigidly supported equipment, i.e., hot water heaters, storage tanks, and the like,

shall be provided with approved seismic control devices, as required, to prevent overturning or sliding.

B. Ceiling supported equipment, including piping shall be provided with approve seismic control devices to maintain the equipment in a captive attitude.

2.13 SEISMIC SNUBBER RESTRAINTS:

A. All floor mounted and resiliently mounted equipment shall be provided with a minimum of four (4) all-direction seismic snubbers. These snubbers shall be double-acting and located as close as possible to vibration isolators to facilitate attachment to equipment base and building structure.

B. Snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials. The elastomeric materials shall be replaceable and a minimum 3/4" thick. Snubbers shall be manufactured with a minimum 1/4" clearance between equipment base mounted section and structure mounted section.

C. Snubber capacity at 3/8" deflection shall be three to four times load assigned to snubber group for equipment.

2.14 VIBRATION ISOLATORS

A. Available Manufacturers:

B. Manufacturers:

1. Ace Mounting Co., Inc.

2. B-Line Systems, Inc.

3. Isolation Technology, Inc.

4. Kinetics Noise Control, Inc.

5. Mason Industries, Inc.

6. Vibration Eliminator Co., Inc.

7. Vibration Mountings & Controls/Korfund.

C. Elastomeric Isolator Pads **<Insert Drawing Designation>**: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: **[Standard neoprene] [Natural rubber] [Bridge-bearing neoprene, complying with AASHTO M 251]**.

2. Durometer Rating: **[30] [40] [45] [50] [60] [65] [70] <Insert number>**.

3. Number of Layers: **[1] [2] [3] [4] <Insert number>**.

D. Elastomeric Mounts **<Insert Drawing Designation>**: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.

1. Durometer Rating: **[30] [40] [45] [50] [60] [65] [70] <Insert number>**.

E. Restrained Elastomeric Mounts **<Insert Drawing Designation>**: All-directional elastomeric mountings with seismic restraint.

1. Materials: Cast-ductile-iron housing containing two separate and opposing, molded, bridge-bearing neoprene elements that prevent central threaded sleeve and attachment bolt from contacting the casting during normal operation.

2. Neoprene: Shock-absorbing materials compounded according to **<Insert referenced standard>**, the standard for bridge-bearing neoprene as defined by AASHTO.

F. Spring Isolators **<Insert Drawing Designation>**: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

2. Minimum Additional Travel: 50 percent of the required deflection at rated load.

3. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 100 psig (690 kPa).

6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

G. Restrained Spring Isolators **<Insert Drawing Designation>**: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

H. Housed Spring Mounts <Insert Drawing Designation>: Housed spring isolator with integral seismic snubbers.

1. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.

2. Base: Factory drilled for bolting to structure.

3. Snubbers: Vertically adjustable to allow a maximum of 1/4-inch (6-mm) travel before contacting a resilient collar.

I. Elastomeric Hangers **<Insert Drawing Designation>**: Double-deflection type, with molded, oil-resistant rubber or neoprene isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.

J. Spring Hangers **<Insert Drawing Designation>**: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.

K. Spring Hangers with Vertical-Limit Stop **<Insert Drawing Designation>**: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.

1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment

without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.

L. Thrust Limits **<Insert Drawing Designation>**: Combination coil spring and elastomeric insert with spring and insert in compression and with a load stop. Include rod and angle-iron brackets for attaching to equipment.

1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.

2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of the required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of the rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.

7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

M. Pipe Riser Resilient Support **<Insert Drawing Designation>**: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick, 60-durometer neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of 500 psig (3.45 MPa) and for equal resistance in all directions.

N. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes separated by a minimum of 1/2-inch- (13-mm-) thick, 60-durometer neoprene. Factory set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

2.15 AIR-MOUNTING SYSTEMS

A. Available Manufacturers:

B. Manufacturers:

1. California Dynamics Corp.

2. Firestone Industrial Products Company.

3. Kinetics Noise Control, Inc.

4. Mason Industries, Inc.

5. Vibration Eliminator Co., Inc.

C. Air Mounts **<Insert Drawing Designation>**: Freestanding, single or multiple, compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.

2. Maximum Natural Frequency: 3 Hz.

3. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).

4. Burst Pressure: At least three times the manufacturer's published maximum operating pressure.

5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

D. Restrained Air Mounts **<Insert Drawing Designation>**: Housed compressed-air bellows.

1. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.

2. Maximum Natural Frequency: 3 Hz.

3. Operating Pressure Range: 25 to 100 psig (172 to 690 kPa).

4. Burst Pressure: At least three times the manufacturer's published maximum operating pressure.

5. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus 1/8 inch (3 mm).

2.16 SEISMIC-RESTRAINT DEVICES

A. Available Manufacturers:

B. Manufacturers:

1. B-Line Systems, Inc.

2. Kinetics Noise Control, Inc.

3. Mason Industries, Inc.

4. Vibration Eliminator Co., Inc.

5. Vibration Mountings & Controls/Korfund.

C. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of **[40] [50] [60]**, plus or minus 5, with a flat washer face.

D. Seismic Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.

1. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.

2. Resilient Isolation Washers and Bushings: 1-piece, molded, bridge-bearing neoprene complying with AASHTO M 251 and having a durometer of **[40] [50] [60]**, plus or minus 5.

E. Restraining Cables: Galvanized steel aircraft cables with end connections made of steel assemblies that swivel to final installation angle and utilize two clamping bolts for cable engagement.

F. Anchor Bolts: Seismic-rated, drill-in, and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488/E 488M.

2.17 VIBRATION ISOLATION EQUIPMENT BASES

A. Available Manufacturers:

B. Manufacturers:

1. Isolation Technology, Inc.

2. Kinetics Noise Control, Inc.

3. Mason Industries, Inc.

4. Vibration Eliminator Co., Inc.

5. Vibration Mountings & Controls/Korfund.

C. Steel Base **<Insert Drawing Designation>**: Factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

D. Inertia Base <Insert Drawing Designation>: Factory-fabricated, welded, structural-steel bases and rails ready for field-applied, cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch (25-mm) clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails. Include supports for suction and discharge elbows for pumps.

2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.

3. Support Brackets: Factory-welded steel angles on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

4. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

2.18 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.

1. Powder coating on springs and housings.

2. All hardware shall be electrogalvanized. Hot-dip galvanize metal components for exterior use.

3. Baked enamel for metal components on isolators for interior use.

4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL:

A. All equipment, piping, etc. shall be mounted on or suspended from approved foundations and supports, all as specified herein, or as shown on the drawings.

B. All rigidly or resiliently installed equipment, piping, etc., shall be capable of accepting seismic forces of 0.50g acting in any direction on the equipment center of gravity without permanent displacement of the equipment from the installed position.

C. All concrete foundations and supports (and required reinforcing and forms) will be furnished and installed by another trade. However, this trade shall furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required hanger bolts and other appurtenances necessary for the proper installation of his equipment. Although another trade will complete all concrete work, all such work shall be shown in detail on the shop drawings, prepared by this trade which drawings shall be submitted showing the complete details of all foundations including necessary concrete and steel work, vibration isolation devices, etc.

D. All floor-mounted equipment shall be erected on 4" high concrete pads over the complete floor area of the equipment, unless specified to the contrary herein. Wherever hereinafter vibration eliminating devices and/or concrete inertia blocks are specified, these items shall, in all cases, be in turn mounted upon 4" high concrete pads unless specified to the contrary herein. These pads shall be integrally keyed to structural slab.

E. The vibration isolation systems shall be guaranteed to have the deflection indicated on the schedule on the drawings. Mounting sizes shall be determined by the mounting manufacturer, and the sizes shall be installed in accordance with the manufacturer's instructions.

F. The installed vibration isolation system for each floor or ceiling supported equipment shall have a maximum lateral motion under equipment start-up or shut down conditions of 1/4 inch. Motions in excess shall be restrained by approved spring type mountings.

G. All mounting systems **[including seismic restraints]** exposed to weather and other corrosive environments shall be protected with factory corrosion resistance. All metal parts of mountings (except springs and hardware) to be hot dip galvanized. Springs shall be cadmium plated and neoprene coated. Nuts and bolts shall be cadmium plated.

H. Where steel spring isolation systems are described in the following specifications, the mounting assemblies shall utilize bare springs with the spring diameter not less than 0.8 of the loaded operating height of the spring. Each spring isolator shall be designed and installed so that the ends of the spring remain parallel during and after the spring installation. All isolators shall operate in the linear portion of their load versus deflection curve and have 50% excess capacity without becoming coil bound.

I. Each seismic restraint, snubbing device or isolation mounting incorporating seismic restraint shall be installed and/or adjusted to provide the minimum operating clearance in all directions to permit the operation of the equipment without objectional noise or vibration to any part of the building structure. The operating clearance for equipment seismic restraints shall not be greater than 1/4 inch.

J. Equipment seismic restraints or snubbing devices and vibration isolation systems mounting shall be the product of one manufacturer.

K. During equipment installation, floor supported spring isolation bases shall be set on 2" spacers between the isolation base and housekeeping pad. After all connections (pipe, duct and conduit) have been made to the equipment and the system filled, the normal operating equipment load shall be transferred from the spacers to the spring isolators. The spacers shall then be removed without change of equipment elevation or transfer of stress to the equipment.

L. Mountings incorporating vertical limit stops shall be furnished and installed with 1/4" spacers. The mountings shall serve as blocking during installation. Mountings shall be adjusted and spacers removed after equipment operating loads.

M. Vibration isolation equipment submittal drawings shall include the following information:

1. Isolation mounting deflections.

2. Spring diameters, compressed spring heights at rated load; solid spring heights, where steel spring isolation mountings are used.

3. Equipment operating speed.

4. Drawings, as required to show the number and location of seismic restraints for each equipment and specified details of restraints including anchor bolts for mountings and maximum load (static plus dynamic expected at each restraint or snubbing device including fastening devices for the seismic restraints which are capable of maintaining equipment in a captive position when subjected to external forces of 0.50g in any direction).

3.3 INSTALLATION

A. Install thrust limits at centerline of thrust, symmetrical on either side of equipment.

B. Install seismic snubbers on isolated equipment. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.

C. Install restraining cables at each trapeze and individual pipe hanger. At trapeze anchor locations, shackle piping to trapeze. Install cables so they do not bend across sharp edges of adjacent equipment or building structure.

D. Install steel angles or channel, sized to prevent buckling, clamped with ductile-iron clamps to hanger rods for trapeze and individual pipe hangers. At trapeze anchor locations, shackle piping to trapeze. Requirements apply equally to hanging equipment. Do not weld angles to rods.

E. Install resilient bolt isolation washers on equipment anchor bolts.

3.4 EQUIPMENT BASES

A. Fill concrete inertia bases, after installing base frame, with **[3000-psi (20.7-MPa)] <Insert other concrete strength>** concrete; trowel to a smooth finish.

1. Cast-in-place concrete materials and placement requirements are specified in Division 3.

B. Concrete Bases: Anchor equipment to concrete base according to supported equipment manufacturer's written instructions for seismic codes at Project site.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of the base.

2. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use Setting Drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

4. Install anchor bolts to elevations required for proper attachment to supported equipment.

5. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

6. Cast-in-place concrete materials and placement requirements are specified in Division 3.

3.5 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified testing agency to perform the following field quality-control testing:

B. Testing: Engage a qualified testing agency to perform the following field quality-control testing:

C. Testing: Perform the following field quality-control testing:

1. Isolator seismic-restraint clearance.

2. Isolator deflection.

3. Snubber minimum clearances.

4. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

5. Air-Mounting System Operational Test: Test the compressed-air leveling system. Remove malfunctioning units, replace with new units, and retest.

6. Test and adjust air-mounting system controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Air-Mounting System Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping connections. Report results in writing.

1. Isolator seismic-restraint clearance.

2. Isolator deflection.

3. Snubber minimum clearances.

4. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

5. Operational Test: Test the compressed-air leveling system. Remove malfunctioning units, replace with new units, and retest.

6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 ADJUSTING

A. Adjust isolators after piping systems have been filled and equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch (6-mm) movement during start and stop.

D. Adjust air spring leveling mechanism.

E. Adjust active height of spring isolators.

F. Adjust snubbers according to manufacturer's written recommendations.

G. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

H. Torque anchor bolts according to equipment manufacturer's written recommendations to resist seismic forces.

3.7 CLEANING

A. After completing equipment installation, inspect vibration isolation and seismic-control devices. Remove paint splatters and other spots, dirt, and debris.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems. Refer to Division 1 Section "**[Closeout Procedures] [Demonstration and Training]**."

3.9 VIBRATION ISOLATOR **[AND SEISMIC-RESTRAINT]** SCHEDULE

A. Supported or Suspended Equipment: **<Insert name and drawing designation.>**

1. Equipment Location: **<Insert room number.>**

2. Isolator Type: **<Insert generic name or designation used in Part 2.>**

3. Base Type: **<Insert generic name or designation used in Part 2.>**

4. Minimum Deflection: **<Insert minimum deflection in inches (mm).>**

5. Component Seismic Coefficient: **<Insert value (ranges from 0.67 to 2.0).>**

6. Performance Criteria Factor: **<Insert value (ranges from 0.5 to 1.5).>**

7. Attachment Amplification Factor: **<Insert value (ranges from 1.0 to 2.0).>**

END OF SECTION 15425

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15430 - PLUMBING - SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following plumbing specialties:
1. Backflow preventers.
2. Water regulators.
3. Balancing valves.
4. Thermostatic water mixing valves.
5. Water tempering valves.
6. Strainers.
7. Hose stations.
8. Key-operation hydrants.
9. Wheel-handle wall hydrants.
10. Trap seal primer valves.
11. Drain valves.
12. Miscellaneous piping specialties.
13. Sleeve penetration systems.
14. Flashing materials.
15. Cleanouts.
16. Floor drains.
17. Trench drains.
18. Roof drains.
19. Solids interceptors.

B. Related Sections include the following:

1. Division 15 Section "Plumbing - Meters and Gages" for water meters, thermometers, and pressure gages.

1.3 DEFINITIONS

A. The following are industry abbreviations for plastic piping materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.

2. PE: Polyethylene plastic.

3. PUR: Polyurethane plastic.

4. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:

1. Domestic Water Piping: 125 psig (860 kPa).

2. Sanitary Waste and Vent Piping: 10-foot head of water (30 kPa).

3. Storm Drainage Piping: 10-foot head of water (30 kPa).

4. Force-Main Piping: 100 psig (690 kPa).

1.5 SUBMITTALS

A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections for the following:

1. Backflow preventers and water regulators.

2. Balancing valves, water filters, and strainers.

3. Thermostatic water mixing valves and water tempering valves.

4. Water hammer arresters, air vents, and trap seal primer valves and systems.

5. Drain valves, hose bibbs, hydrants, and hose stations.

6. Outlet boxes and washer-supply outlets.

7. cleanouts, floor drains, open receptors, trench drains, and roof drains.

8. Air-admittance valves, vent caps, vent terminals, and roof flashing assemblies.

9. solids interceptors.

10. Sleeve penetration systems.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field test reports.

D. Maintenance Data: For plumbing specialties to include in maintenance manuals. Include the following:

1. Backflow preventers and water regulators.

2. Thermostatic water mixing valves and water tempering valves.

3. Trap seal primer valves and systems.

4. Hose stations and hydrants.

5. solids interceptors.

1.6 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of plumbing specialties and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Plumbing specialties shall bear label, stamp, or other markings of specified testing agency.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.

E. NSF Compliance:

1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-pw" on plastic potable-water piping and "NSF-dwv" on plastic drain, waste, and vent piping.

2. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Water Filter Cartridges: Equal to 200 percent of amount installed for each type and size indicated.

2. Operating Key Handles: Equal to 100 percent of amount installed for each key-operated hose bibb and hydrant installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the products specified.

2.2 BACKFLOW PREVENTERS

A. Manufacturers:

1. Ames Co., Inc.

2. Cla-Val Co.

3. CMB Industries, Inc.; Febco Backflow Preventers.

4. Mueller Co.; Hersey Meters Div.

5. Watts Industries, Inc.; Water Products Div.

6. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE standard, backflow preventers.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

2. NPS 2-1/2 (DN 65) and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.

(a) Interior Lining: AWWA C550 or FDA-approved, epoxy coating for backflow preventers having cast-iron or steel body.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping

system.

5. Strainer: On inlet.

C. Pipe-Applied, Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.

D. Hose-Connection Vacuum Breakers: ASSE 1011, nickel plated, with nonremovable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.

E. Intermediate Atmospheric-Vent Backflow Preventers: ASSE 1012, suitable for continuous pressure application. Include inlet screen and two independent check valves with intermediate atmospheric vent.

F. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

G. Double-Check Backflow Prevention Assemblies: ASSE 1015, suitable for continuous pressure application. Include shutoff valves on inlet and outlet, and strainer on inlet; test cocks; and two positive-seating check valves.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

H. Antisiphon-Pressure-Type Vacuum Breakers: ASSE 1020, suitable for continuous pressure application. Include shutoff valves, spring-loaded check valve, spring-loaded floating disc, test cocks, and atmospheric vent.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

I. Dual-Check-Valve-Type Backflow Preventers: ASSE 1024, suitable for continuous pressure application. Include union inlet and two independent check valves.

J. Dual-Check-Valve-Type Backflow Preventers: ASSE 1032, suitable for continuous pressure application for carbonated beverage dispensers. Include stainless-steel body; primary and secondary checks; ball check; intermediate atmospheric-vent port for relieving carbon dioxide; and threaded ends, NPS 3/8 (DN 10).

K. Reduced-Pressure Detector Assembly Backflow Preventers: ASSE 1047, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves; and bypass with displacement-type water meter, valves, and reduced-pressure backflow preventer.

1. Pressure Loss: 12 psig (83 kPa) maximum, through middle 1/3 of flow range.

L. Double-Check Detector Assembly Backflow Preventers: ASSE 1048, FM approved or UL listed, and suitable for continuous pressure application. Include outside screw and yoke gate valves on inlet and outlet, and strainer on inlet. Include test cocks; two positive-seating check valves; and bypass with displacement-type water meter, valves, and double-check backflow preventer.

1. Pressure Loss: 5 psig (35 kPa) maximum, through middle 1/3 of flow range.

M. Hose-Connection Backflow Preventers: ASSE 1052, suitable for at least 3-gpm (0.19-L/s) flow and applications with up to 10-foot head of water (30-kPa) back pressure. Include two check valves; intermediate atmospheric vent; and nonremovable, ASME B1.20.7, garden-hose threads on outlet.

N. Back-Siphonage Backflow Vacuum Breakers: ASSE 1056, suitable for continuous pressure and backflow applications. Include shutoff valves, check valve, test cocks, and vacuum vent.

2.3 WATER REGULATORS

A. Manufacturers:.

1. Cla-Val Co..

2. Watts Industries, Inc.; Water Products Div.

3. Zurn Industries, Inc.; Wilkins Div.

B. General: ASSE 1003, water regulators, rated for initial working pressure of 150 psig (1035 kPa) minimum. Include integral factory-installed or separate field-installed, Y-pattern strainer.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.

(a) General-Duty Service: Single-seated, direct operated, unless otherwise indicated.

(b) Booster Heater Water Supply: Single-seated, direct operated with integral bypass.

2. NPS 2-1/2 (DN 65) and Larger: Bronze or cast-iron body with flanged ends. Include AWWA C550 or FDA-approved, interior epoxy coating for regulators with cast-iron body.

(a) Type: Single-seated, direct operated.

(b) Type: Pilot-operated, single- or double-seated, cast-iron-body main valve, with bronze-body pilot valve.

3. Interior Components: Corrosion-resistant materials.

4. Exterior Finish: Polished chrome plate if used in chrome-plated piping system.

5. Strainer on inlet.

2.4 BALANCING VALVES

A. Balancing Valves: Adjustable, with two readout ports and memory setting indicator. Include manufacturer's standard hoses, fittings, valves, differential pressure meter, and carrying case.

1. Manufacturers:

(a) Amtrol, Inc.

(b) Armstrong Pumps, Inc.

(c) Armstrong-Yoshitake, Inc..

(d) ITT Industries; Bell & Gossett Div.

(e) Taco, Inc.

(f) Watts Industries, Inc.; Water Products Div.

2. NPS 2 (DN 50) and Smaller: Bronze body with brass ball, adjustment knob, calibrated nameplate, and threaded or solder-joint ends.

3. NPS 2 (DN 50) and Smaller: Bronze, Y-pattern body with adjustment knob and threaded ends.

4. NPS 2-1/2 (DN 65) and Larger: Cast-iron, Y-pattern body with bronze disc and flanged or grooved ends.

2.5 THERMOSTATIC WATER MIXING VALVES 60° - 85°

A. Manufacturers:

1. Lawler Manufacturing Company, Inc.

2. Leonard Valve Company.

3. Mark Controls Corp.; Powers Process Controls.

4. Symmons Industries, Inc.

B. General: ASSE 1017, manually adjustable, thermostatic water mixing valve with bronze body. Include check stop and union on hot- and cold-water-supply inlets, adjustable temperature setting, and thermometer.

1. Type: Bimetal thermostat, operation and pressure rating 125 psig (860 kPa) minimum.

2. Type: Liquid-filled motor, operation and pressure rating 100 psig (690 kPa) minimum.

C. Thermostatic Water Mixing Valves: Unit, with the following:

1. Piping, valves, and unions. Include thermometer if not in cabinet.

2. Piping Component Finish: Polished chrome plate.

3. Cabinet: [**Recessed**] [**Surface**]-mounting steel box with steel hinged door, white enameled finish, and thermometer in front.

4. Cabinet: [**Recessed**] [**Surface**]-mounting stainless-steel box with stainless-steel hinged door and thermometer in front.

D. Manifolded, Thermostatic Water Mixing-Valve Assemblies: Factory-fabricated unit consisting of parallel arrangement of thermostatic water mixing valves.

1. Arrangement: One large-flow, thermostatic water mixing valve with flow-control valve, pressure regulator, inlet and outlet pressure gages, and one small-flow, thermostatic water mixing valve with flow-control valve. Include outlet thermometer, factory- or field-installed inlet and outlet valves, and other indicated options.

2. Include piping, valves, and unions.

3. Piping Component Finish: Polished chrome plate.

4. Cabinet: [**Recessed**] [**Surface**]-mounting steel box with steel hinged door, white enameled finish, and thermometer in front.

5. Cabinet: [**Recessed**] [**Surface**]-mounting stainless-steel box with stainless-steel hinged door and thermometer in front.

2.6 WATER TEMPERING VALVES

A. Manufacturers:

1. Holby Valve Co., Inc.

2. Watts Industries, Inc.; Water Products Div.

B. General: Manually adjustable, thermostatically controlled water tempering valve; bronze body; and adjustable temperature setting.

C. System Water Tempering Valves: Piston or discs controlling both hot- and cold-water flow, capable of limited antiscald protection. Include threaded inlets and outlet.

1. Finish: Chrome plated.

D. Limited-Volume, Water Tempering Valves: Solder-joint inlets and NPS 3/4 (DN 20) maximum outlet.

2.7 STRAINERS

A. Strainers: Y-pattern, unless otherwise indicated, and full size of connecting piping. Include ASTM A 666, Type 304, stainless-steel screens with 3/64-inch (1.2-mm) round perforations, unless otherwise indicated.

1. Pressure Rating: 125-psig (860-kPa) minimum steam working pressure, unless otherwise indicated.

2. NPS 2 (DN 50) and Smaller: Bronze body, with female threaded ends.

3. NPS 2-1/2 (DN 65) and Larger: Cast-iron body, with interior AWWA C550 or FDA-approved, epoxy coating and flanged ends.

4. Y-Pattern Strainers: Screwed screen retainer with centered blowdown.

(a) Drain: Factory- or field-installed, hose-end drain valve.

5. T-Pattern Strainers: Malleable-iron or ductile-iron body with grooved ends; access end cap with drain plug and access coupling with rubber gasket.

6. Basket Strainers: Bolted flange or clamp cover, and basket with lift-out handle.

(a) Type: Simplex with one basket.

(b) Drain: Factory- or field-installed, hose-end drain valve.

B. Drainage Basket Strainers: Non-pressure-rated, cast-iron or coated-steel body; with bolted flange or clamp cover and drain with plug.

1. Basket: Bronze or stainless steel with 1/8- or 3/16-inch- (3.2- or 4.8-mm-) diameter holes and lift-out handle.

2. Female threaded ends for NPS 2 (DN 50) and smaller, and flanged ends for NPS 2-1/2 (DN 65) and larger.

2.8 KEY-OPERATION HYDRANTS

A. Manufacturers:

1. Josam Co.

2. Murdock, Inc.

3. Simmons Manufacturing Co.

4. Smith, Jay R. Mfg. Co.

5. Tyler Pipe; Wade Div.

6. Watts Industries, Inc.; Drainage Products Div.

7. Woodford Manufacturing Co.

8. Zurn Industries, Inc.; Jonespec Div.

9. Zurn Industries, Inc.; Specification Drainage Operation.

B. General: ASME A112.21.3M, key-operation hydrant with pressure rating of 125 psig (860 kPa).

1. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25) threaded or solder joint.

2. Outlet: ASME B1.20.7, garden-hose threads.

3. Operating Keys: Two with each key-operation hydrant.

C. Nonfreeze Exposed-Outlet Wall Hydrants: ASSE 1019, self-drainable with integral nonremovable hose-connection [**vacuum breaker**] [**or**] [**backflow preventer**], casing and operating rod to match wall thickness, projecting outlet, and wall clamp.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.

2. Nozzle and Wall Plate Finish: Polished nickel bronze.

D. Nonfreeze Concealed-Outlet Wall Hydrants: ASSE 1019, self-drainable with flush-mounting box with cover, integral nonremovable hose-connection vacuum breaker or backflow preventer, casing and operating rod to match wall thickness, concealed outlet, and wall clamp.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.

2. Box and Cover Finish: Polished nickel bronze.

E. Moderate-Climate, Concealed-Outlet Wall Hydrants: ASSE 1019, self-drainable with flush-mounting box with cover, integral nonremovable hose-connection vacuum breaker or backflow preventer, and concealed outlet.

1. Classification: Type A, for automatic draining with hose removed or Type B, for automatic draining with hose removed or with hose attached and nozzle closed.

2. Box and Cover Finish: Polished nickel bronze.

3. Box and Cover Finish: [**Satin**] [**Polished**] chrome plate.

F. Hot and Cold, Nonfreeze Concealed-Outlet Wall Hydrants: With deep flush-mounting box with cover; hot- and cold-water casings and operating rods to match wall thickness; concealed outlet; wall clamps; and factory- or field-installed, nonremovable and manual drain-type, hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052.

1. Box and Cover Finish: Polished nickel bronze.

G. Nonfreeze Concealed-Outlet Ground Hydrants: Draining type with flush-mounting box with cover, casing and operating rod of at least length required for burial of valve below frost line, drain hole, and garden-hose threads complying with ASME B1.20.7 on outlet.

1. Box and Cover Finish: Polished nickel bronze.

H. Nonfreeze Exposed-Outlet Ground Post Hydrants: Draining type for key or lever operation with bronze casing, cast-iron, or cast-aluminum casing guard; casing and operating rod of at least length required for burial of valve below frost line; drain hole; nonremovable, drainable hose-connection vacuum breaker complying with ASSE 1011 or backflow preventer complying with ASSE 1052; and garden-hose threads complying with ASME B1.20.7 on outlet.

2.9 WHEEL-HANDLE WALL HYDRANTS

A. Manufacturers:

1. Arrowhead Brass Products, Inc.

2. B & K Industries, Inc.

3. Mansfield Plumbing Products, Inc.

4. NIBCO INC.

5. Sioux Chief Manufacturing Co., Inc.

6. Watts Industries, Inc.; Water Products Div.

7. Woodford Manufacturing Co.

8. Zurn Industries, Inc.; Jonespec Div.

B. Description: Frost-proof design similar to ASME A112.21.3M, for wall mounting with wheel-handle operation, NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet, casing and operating rod to match wall thickness, and projecting outlet with ASME B1.20.7 garden-hose threads on outlet. Include wall clamp; integral vacuum breaker or nonremovable, drainable hose-connection vacuum breaker complying with ASSE 1011] [or] [backflow preventer complying with ASSE 1052; and garden-hose threads complying with ASME B1.20.7 on outlet.

2.10 TRAP SEAL PRIMER VALVES

A. Supply-Type Trap Seal Primer Valves: ASSE 1018, water-supply-fed type, with the following characteristics:

1. Manufacturers:

(a) Josam Co.

(b) MIFAB Manufacturing, Inc.

(c) Precision Plumbing Products, Inc.

(d) Smith, Jay R. Mfg. Co.

(e) Tyler Pipe; Wade Div.

(f) Watts Industries, Inc.; Drainage Products Div.

(g) Watts Industries, Inc.; Water Products Div.

(h) Zurn Industries, Inc.; Jonespec Div.

(i) Zurn Industries, Inc.; Specification Drainage Operation.

2. 125-psig (860-kPa) minimum working pressure.

3. Bronze body with atmospheric-vented drain chamber.

4. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.

5. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.

6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.11 DRAIN VALVES

A. Hose-End Drain Valves: MSS SP-110, NPS 3/4 (DN 20) ball valve, rated for 400-psig (2760-kPa) minimum CWP. Include two-piece, copper-alloy body with standard port, chrome-plated brass ball, replaceable seats and seals, blowout-proof stem, and vinyl-covered steel handle.

1. Inlet: Threaded or solder joint.

2. Outlet: Short-threaded nipple with ASME B1.20.7, garden-hose threads and cap.

B. Hose-End Drain Valve: MSS SP-80, gate valve, Class 125, ASTM B 62 bronze body, with NPS 3/4 (DN 20) threaded or solder-joint inlet and ASME B1.20.7, garden-hose threads on outlet and cap. Hose bibbs are prohibited for this application.

C. Stop-and-Waste Drain Valves: MSS SP-110, ball valve, rated for 200-psig (1380-kPa) minimum CWP or MSS SP-80, Class 125, gate valve; ASTM B 62 bronze body, with NPS 1/8 (DN 6) side drain outlet and cap.

2.12 MISCELLANEOUS PIPING SPECIALTIES

A. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, metal-bellows type with pressurized metal cushioning chamber. Sizes indicated are based on ASSE 1010 or PDI-WH 201, Sizes A through F.

1. Manufacturers:

(a) Josam Co.

(b) Smith, Jay R. Mfg. Co.

(c) Tyler Pipe; Wade Div.

(d) Zurn Industries, Inc.; Specification Drainage Operation.

B. Water Hammer Arresters: ASSE 1010 or PDI-WH 201, piston type with pressurized metal-tube cushioning chamber. Sizes indicated are based on ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

1. Available Manufacturers:

(a) Amtrol, Inc.

(b) Josam Co.

(c) Precision Plumbing Products, Inc.

(d) Sioux Chief Manufacturing Co., Inc.

(e) Watts Industries, Inc.; Drainage Products Div.

(f) Watts Industries, Inc.; Water Products Div.

(g) Zurn Industries, Inc.; Wilkins Div.

C. Hose Bibbs: Bronze body with replaceable seat disc complying with ASME A112.18.1M for compression-type faucets. Include NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet, of design suitable for pressure of at least 125 psig (860 kPa); integral [or field-installed,] nonremovable, drainable hose-connection vacuum breaker; and garden-hose threads complying with ASME B1.20.7 on outlet.

1. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.

2. Finish for Service Areas: Chrome or nickel plated.

3. Finish for Finished Rooms: Chrome or nickel plated.

4. Operation for Equipment Rooms: Wheel handle or operating key.

5. Operation for Service Areas: Wheel handle.

6. Operation for Finished Rooms: Operating key.

7. Include operating key with each operating-key hose bibb.

8. Include integral wall flange with each chrome- or nickel-plated hose bibb.

D. Air Vents: Float type for automatic air venting.

1. Bolted Construction: Bronze body with replaceable, corrosion-resistant metal float and stainless-steel mechanism and seat; threaded NPS 1/2 (DN 15) minimum inlet; 125-psig (860-kPa) minimum pressure rating at 140 deg F (60 deg C); and threaded vent outlet.

2. Welded Construction: Stainless-steel body with corrosion-resistant metal float, stainless-steel mechanism and seat, threaded NPS 3/8 (DN 10) minimum inlet, 150-psig (1035-kPa) minimum pressure rating, and threaded vent outlet.

E. Roof Flashing Assemblies: Manufactured assembly made of[**6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch- (2.4-mm-)**] thick, lead flashing collar and skirt extending at least **[10 inches (250 mm)**] from pipe with galvanized steel boot reinforcement, and counterflashing fitting.

1. Manufacturer:

(a) Acorn Engineering Company; Elmdor/Stoneman Div.

2. Open-Top Vent Cap: Without cap.

3. Low-Silhouette Vent Cap: With vandal-proof vent cap.

4. Extended Vent Cap: With field-installed, vandal-proof vent cap.

F. Open Drains: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting, joined with ASTM C 564, rubber gaskets.

G. Deep-Seal Traps: Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap seal primer valve connection.

1. NPS 2 (DN 50): 4-inch- (100-mm-) minimum water seal.

2. NPS 2-1/2 (DN 65) and Larger: 5-inch- (125-mm-) minimum water seal.

H. Floor-Drain Inlet Fittings: Cast iron, with threaded inlet and threaded or spigot outlet, and trap seal primer valve connection.

I. Fixed Air-Gap Fittings: Manufactured cast-iron or bronze drainage fitting with semiopen top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.

J. Stack Flashing Fittings: Counterflashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.

K. Vent Caps: Cast-iron body with threaded or hub inlet and vandal-proof design. Include vented hood and set-screws to secure to vent pipe.

L. Vent Terminals: Commercially manufactured, shop- or field-fabricated, frost-proof assembly constructed of galvanized steel, copper, or lead-coated copper. Size to provide 1-inch (25-mm) enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

M. Downspout Boots: ASTM A 48 (ASTM A 48M), gray-iron casting, with NPS 4 (DN 100) outlet; shop-applied bituminous coating; and inlet size to match downspout.

N. Downspout Boots: ASTM A 74, Service class, hub-and-spigot, cast-iron soil pipe.

O. Conductor Nozzles: Bronze body with threaded inlet for connected conductor size, and bronze wall flange with mounting holes.

1. Finish: [**Polished**] [**Nickel**] bronze.

2.13 SLEEVE PENETRATION SYSTEMS

A. Manufacturer:

1. ProSet Systems, Inc.

B. Description: UL 1479, through-penetration firestop assembly consisting of sleeve and stack fitting with firestopping plug.

1. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.

2. Stack Fitting: ASTM A 48 (ASTM A 48M), gray-iron, hubless-pattern, wye-branch stack fitting with neoprene O-ring at base and gray-iron plug in thermal-release harness in branch. Include PVC protective cap for plug.

(a) Special Coating: Include corrosion-resistant interior coating on fittings for plastic chemical waste and vent stacks.

2.14 FLASHING MATERIALS

A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following

minimum weights and thicknesses, unless otherwise indicated:

1. General Use: 4-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness.

2. Vent Pipe Flashing: 3-lb/sq. ft. (15-kg/sq. m), 0.0469-inch (1.2-mm) thickness.

3. Burning: 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness.

B. Copper Sheet: ASTM B 152 (ASTM B 152M), of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft. (3.7 kg/sq. m or 0.41-mm thickness).

2. Vent Pipe Flashing: 8 oz./sq. ft. (2.5 kg/sq. m or 0.27-mm thickness).

C. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch (1.01-mm) minimum thickness, unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.

D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil (1.01-mm) minimum thickness.

E. Fasteners: Metal compatible with material and substrate being fastened.

F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.

G. Solder: ASTM B 32, lead-free alloy.

H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.15 CLEANOUTS

A. Cleanouts: Comply with ASME A112.36.2M and ASME A112.3.1.

1. Application: Floor cleanout, wall cleanout and for installation in exposed piping.

2. Manufacturers:

(a) Josam Co.;

(b) Josam Co., Blucher-Josam Div.

(c) Smith, Jay R. Mfg. Co.;

(d) Tyler Pipe, Wade Div.;

(e) Watts Industries, Inc., Drainage Products Div.;

(f) Zurn Industries, Inc., Jonespec Div.;

(g) Zurn Industries, Inc., Specification Drainage Operation;

3. Body or Ferrule Material: [**Cast iron**].

4. Clamping Device: As required.

5. Outlet Connection: Threaded, inside calk or spigot.

6. Closure: Brass plug with straight threads and gasket.

7. Adjustable Housing Material: Cast iron with threads, set-screws or other device.

8. Frame and Cover Material and Finish: Nickel-bronze, copper, polished bronze or stainless steel.

9. Frame and Cover Shape: Round.

10. Top Loading Classification: Light Duty, medium Duty, heavy Duty, extra Heavy-Duty or special Duty.

2.16 FLOOR, ROOF, TRENCH, DRAINS (SEE SCHEDULE ON DRAWINGS)

A. Floor, Roof, Trench, Drains: Comply with ASME A112.21.1M and ASME A112.21.1M with ASME A112.14.1, backwater valve, ASME A112.3.1.

1. Application: Area drain, Floor drain, Funnel floor drain, etc.

2. Manufacturers:

(a) Josam Co., Blucher-Josam Div.;

(b) Smith, Jay R. Mfg. Co.;

(c) Tyler Pipe, Wade Div.;

(d) Watts Industries, Inc., Drainage Products Div.;

(e) Zurn Industries, Inc., Jonespec Div.;

(f) Zurn Industries, Inc., Specification Drainage Operation;

2.17 GREASE INTERCEPTORS (SEE DESCRIPTION ON DRAWINGS)

2.18 SOLIDS INTERCEPTORS

A. Solids Interceptors:

1. Manufacturers:

(a) Josam Co.;

(b) MIFAB Manufacturing, Inc.;

(c) Rockford Sanitary Systems, Inc.;

(d) Schier Products Co.;

(e) Smith, Jay R. Mfg. Co.;

(f) Town & Country Plastics, Inc.;

(g) Tyler Pipe, Wade Div.;

(h) Watts Industries, Inc., Drainage Products Div.;
(i) Zurn Industries, Inc., Specification Drainage Operation;

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to Division 15 Section 15051 "Basic Plumbing Materials and Methods" for piping joining materials, joint construction, and basic installation requirements.

B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.

1. Locate backflow preventers in same room as connected equipment or system.

2. Install drain for backflow preventers with atmospheric-vent drain connection with air-gap fitting, fixed air-gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air-gap device attached to or under backflow preventer. Simple air breaks are not acceptable for this application.

3. Do not install bypass piping around backflow preventers.

C. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.

D. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.

E. Install draining-type ground or ground post hydrants with 1 cu. yd. (0.75 cu. m) of crushed gravel around drain hole.

1. Set ground hydrants with box flush with grade.

2. Set post hydrants in concrete paving or in 1 cu. ft. (0.03 cu. m) of concrete block at grade.

F. Install trap seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

G. Install expansion joints on vertical risers, stacks, and conductors if indicated.

H. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet (15 m).
4. Locate at base of each vertical soil and waste stack.

I. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.

J. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.

K. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.

L. Install vent flashing sleeves on stacks passing through roof. Secure over stack flashing according to manufacturer's written instructions.

M. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch (25-mm) clearance between vent pipe and roof substrate.

N. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

1. Position floor drains for easy access and maintenance.
2. Set floor drains below elevation of surrounding finished floor to allow floor drainage.
3. Set with grates depressed according to the following drainage area radii:

(a) Radius, 30 Inches (750 mm) or Less: Equivalent to 1 percent slope, but not less than 1/4-inch (6.35-mm) total depression.

(b) Radius, 30 to 60 Inches (750 to 1500 mm): Equivalent to 1 percent slope.

(c) Radius, 60 Inches (1500 mm) or Larger: Equivalent to 1 percent slope, but not greater than 1-inch (25-mm) total depression.

4. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.

5. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

O. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions.

1. Install roof-drain flashing collar or flange so no leakage occurs between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.

2. Position roof drains for easy access and maintenance.

P. Install interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing.

1. Above-Floor Installation: Set unit with bottom resting on floor, unless otherwise indicated.

2. Flush with Floor Installation: Set unit and extension, if required, with cover flush with finished floor.

3. Recessed Floor Installation: Set unit in receiver housing having bottom or cradle supports, with receiver housing cover flush with finished floor.

4. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.

5. Coordinate oil-interceptor storage tank and gravity drain with Division 2 Section "Fuel-Oil Distribution."

Q. Install grease recovery units on floor. Install trap, vent, and flow-control fitting according to authorities having jurisdiction.

1. Install control panel adjacent to unit, unless otherwise indicated.

R. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.

S. Fasten recessed-type plumbing specialties to reinforcement built into walls.

T. Install wood-blocking reinforcement for wall-mounting and recessed-type plumbing specialties.

U. Install individual shutoff valve in each water supply to plumbing specialties. Use ball, gate, or globe valve if specific valve is not indicated. Install shutoff valves in accessible locations. Refer to Division 15 Section "Plumbing - Valves" for general-duty ball, butterfly, check, gate, and globe valves.

V. Install air vents at piping high points. Include ball, gate, or globe valve in inlet and drain piping from outlet to floor drain.

W. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.

X. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to equipment to allow service and maintenance.

C. Connect plumbing specialties to piping specified in other Division 15 Sections.

D. Ground equipment.

E. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

F. Connect plumbing specialties and devices that require power according to Division 16 Sections.

G. Interceptor Connections: Connect piping, flow-control fittings, and accessories.

1. Grease Interceptors: Connect inlet and outlet to unit, and flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit.

2. Grease Recovery Units: Connect inlet, outlet, and vent piping; controls; electric power; and factory-furnished accessories to unit.

3. Oil Interceptors: Connect inlet, outlet, vent, and gravity drawoff piping to unit; flow-control fitting and vent to unit inlet piping; and gravity drawoff and suction piping to oil storage tank.

4. Solids Interceptors: Connect inlet and outlet.

3.3 FLASHING INSTALLATION

A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:

1. Lead Sheets: Burn joints of lead sheets 6-lb/sq. ft. (30-kg/sq. m), 0.0938-inch (2.4-mm) thickness or thicker. Solder joints of lead sheets 4-lb/sq. ft. (20-kg/sq. m), 0.0625-inch (1.6-mm) thickness or thinner.

2. Copper Sheets: Solder joints of copper sheets.

B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.

1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches (250 mm), and skirt or flange extending at least 8 inches (200 mm) around pipe.

2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around sleeve.
3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches (200 mm) around specialty.

C. Set flashing on floors and roofs in solid coating of bituminous cement.

D. Secure flashing into sleeve and specialty clamping ring or device.

E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 7 Section "Sheet Metal Flashing and Trim."

F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast-iron sleeve having calking recess.

G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.4 LABELING AND IDENTIFYING

A. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplate or sign on or near each piece of equipment.

1. Text: Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit.

2. Refer to Division 15 Sections "Basic Plumbing Materials and Methods” and “Plumbing - Identification" for nameplates and signs.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled grease recovery units and their installation, including piping and electrical connections. Report results in writing.

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.6 PROTECTION

A. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain each piece of equipment. Refer to Division 1 Sections "Closeout Procedures” and/or “Demonstration and Training."

END OF SECTION 15430

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic hot-water circulation:

1. Close-coupled, in-line, sealless centrifugal pumps.

B. Related Sections include the following:

1. Division 2 Section "Water Supply Wells" for well pumps.
2. Division 15 Section "Plumbing - Packaged Booster Pumps" for booster systems.

1.3 SUBMITTALS

A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, and are limited to, manufacturers specified.

2.2 CLOSE COUPLED, IN-LINE, SEALLESS CENTRIFUGAL PUMPS

A. Manufacturers:

1. Armstrong Pumps Inc.
2. Bell & Gossett Domestic Pump; ITT Industries.
3. Grundfos Pumps Corp.
4. Patterson Pump Co.
5. Taco, Inc.

B. Description: Factory-assembled and -tested, single-stage, close-coupled, in-line, sealless centrifugal pumps as defined in HI 5.1-5.6.

1. Pump and Motor Assembly: Hermetically sealed, replaceable-cartridge-type unit with motor and impeller on common shaft and designed for installation with pump and motor shaft mounted horizontally.

2. Casing: Bronze, with threaded companion-flange connections.

3. Impeller: Corrosion-resistant material

4. Motor: Single speed, unless otherwise indicated. Comply with requirements in Division 15 Section "Motors."

C. Capacities and Characteristics: As Scheduled on the Drawings.

2.3 CONTROLS

A. Thermostats: Electric; adjustable for control of hot-water circulation pump.

1. Manufacturers:

   a. Honeywell International, Inc.
   b. Square D.
   c. White-Rodgers Div.; Emerson Electric Co.

2. Type: Water-immersion sensor, for installation in hot-water circulation piping.
3. Range: **50 to 125 deg F (10 to 52 deg C)**.
4. Operation of Pump: On or off.
5. Transformer: Provide if required.
6. Power Requirement:[**120 V, ac**]
7. Settings: Start pump at **115 deg F (46 deg C)** and stop pump at **120 deg F (49 deg C)**

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine roughing-in of domestic-water-piping system to verify actual locations of connections before pump installation.

3.2 PUMP INSTALLATION

A. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

B. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

C. Install in-line, sealless centrifugal pumps with motor and pump shafts horizontal.

D. Install continuous-thread hanger rods and spring hangers sufficient size to support pump weight. Vibration isolation devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 15 Section "Hangers and Supports."

3.3 CONTROL INSTALLATION

A. Install immersion-type thermostats in hot-water return piping.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to pumps to allow service and maintenance.

C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 15 Section "Plumbing - Domestic Water Piping."

1. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 15 Section "Plumbing - Valves" for general-duty valves for domestic water piping and Division 15 Section "Plumbing Specialties" for strainers.

2. Install pressure gages at suction and discharge of pumps. Install at integral pressure-gage tappings where provided or install pressure-gage connectors in suction and discharge piping around pumps. Refer to Division 15 Section "Meters and Gages" for pressure gages and gage connectors.

3. Install thermometer on discharge of pump.

D. Ground equipment according to Division 16 Section "Grounding and Bonding."

E. Connect wiring according to Division 16 Section "Conductors and Cables."

F. Connect thermostats to pumps that they control.

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

2. Check piping connections for tightness.

3. Clean strainers on suction piping.

4. Set thermostats and timers for automatic starting and stopping operation of pumps.

5. Perform the following startup checks for each pump before starting:

a. Verify bearing lubrication.

b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.

c. Verify that pump is rotating in the correct direction.

6. Prime pump by opening suction valves and closing drains, and prepare pump for operation.

7. Start motor.

8. Open discharge valve slowly.

9. Adjust temperature settings on thermostats.

10. Adjust timer settings.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain controls and pumps. Refer to Division 1 Section "Closeout Procedures” and/or “Demonstration and Training."

END OF SECTION 15441

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes variable-speed, triplex, packaged booster pumps for domestic water piping systems.

B.

C. Related Sections include the following:

1. Division 15 Section "Domestic Water Pumps" for domestic water circulation pumps.

1.3 SUBMITTALS

A. Product Data: For each packaged booster pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.

B. Shop Drawings: For packaged booster pumps and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. For installed products indicated to comply with design loads, include structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.

3. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

4. Wiring Diagrams: Detail power, signal, and control wiring.

C. Manufacturer Seismic Qualification Certification: Submit certification that packaged booster pumps, accessories, and components will withstand seismic forces defined in Division 15 Section "Plumbing - Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Operation and Maintenance Data: For each packaged booster pump to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of packaged booster pumps and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. ASME Compliance: Comply with ASME B31.9 for piping.

D. Packaged booster pumps shall be listed and labeled as pumping systems by testing agency acceptable to authorities having jurisdiction.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Retain shipping flange protective covers and protective coatings during storage.

B. Protect bearings and couplings against damage.

C. Comply with pump manufacturer's written rigging instructions for handling.

1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, and are limited to, manufacturers specified.
   A. Synroflo
   B. ITT Bell & Gossett
   C. Tigerflo
   D. Canariis Corp

2.2 VARIABLE-SPEED, TRIPLEX BOOSTER PUMPS

A. Description: Factory-assembled and -tested, packaged booster pump with multiple pumps, piping, valves, sensors, and controls on skids or base.

B. System Working-Pressure Rating: **150 psig (1035 kPa)** minimum.

C. Pump Arrangement: Triplex, with one small lead and two large equal-size lag main pumps.

D. Furnish and install a prefabricated variable speed IronHeart horizontal water pressure booster system as manufactured by SyncroFlo, Inc., Norcross, GA. The Lead Pump shall deliver 37 GPM at 92' FT TDH with 3HP/3450/460/3/60 motor and Each Lag Pump . Each pump shall deliver 73 GPM at 92' FT TDH with 5HP/3450/460/3/60 motors. The system shall include 4" stainless steel suction and discharge headers with flanged connections. Each header shall include a flanged flexible connector with floating flanges, single sphere EPDM elastomer.

E. Code Compliance **-** All packaged equipment shall be independently Third Party labeled as a system suitable for the intended use by a Nationally Recognized Testing Laboratory in accordance with OSHA Federal Regulations, and NFPA Pamphlet 70, National Electric Code Article 90-7.

F. Manufacturer's Qualifications - Pump system manufacturer must have no less than 20 years experience as a designer and manufacturer of domestic water pumping systems for commercial buildings.

G. Pumps shall be single stage end-suction design with cast iron bronze-fitted construction, equipped with sleeve-mounted mechanical shaft seals and close coupled to a high efficiency motor with class F insulation. Pump designs that do not have shaft sleeves shall not be acceptable. Pump shall be fitted with single inside mechanical seal with carbon vs. ceramic faces, stainless steel spring and hardware and Buna-N elastomers. Pumps shall be selected closest to the best efficiency point. Motors shall be non-overloading at duty point.

H. To protect the pump against overheating, provide a mechanical over-temperature protection device on the pump discharge that will divert flow to drain when water temperature exceeds 140° F.

I. Provide isolation valves on the suction and discharge of each pump. Valves shall be lug style butterfly valves with hand lever operator rated for a minimum 200psig W.P. All contact surfaces shall be suitable for potable water service. Gate valves shall not be acceptable.

J. Check Valves - Provide a wafer style spring loaded check valve to prevent back flow of water on each pump suction and discharge. Check valve shall be manufactured from gray iron and shall be rated for a minimum of 200psig W.P. All contact surfaces shall be suitable for potable water service.

K. Pump Sequencing - The controller shall sequence pumps based on flow readings from an insertion type paddlewheel flow sensor. As a backup, a factory set pressure switch shall sequence pumps when system pressure falls below the setpoint. Automatic sequencing shall include the following features:

1. Sequence shifting that adjusts the pump sequence when any pump is disabled
2. Successive and 24 hour alternation of equal capacity pumps
3. Pump overlap during 24-hour alternation
4. Lag pump exerciser function
5. Special sequencing to reduce surges during power restoration
6. Sequential sequencing of lag pumps
7. Minimum run and stop delay timer for each pump
8. Field adjustable time delay for lag pump pressure start signals
9. Field adjustable low suction pressure alarm
10. Field adjustable selection to enable / disable limited auto reset of low suction and high system pressure alarms

L. Energy Saving - Water Storage Tank - Provide a factory pre-charged, **185** gallon **200 PSI Rated** ASME code and NB stamped, HydroCumulator tank. Tank shall include a replaceable FDA approved Butyl rubber flexible membrane to separate air and water. No water shall come in contact with the walls of the tank. The HydroCumulator tank shall be shipped pre-charged to the proper design conditions. Provide pressure switch and flow sensor to automatically control lead pump operation. These controls shall prevent lead pump short-cycling while maximizing the stored water available from the HydroCumulator tank. The tank shall be located near the top of the building, as indicated on the plans. Contractor shall install the tank and provide floor drain as required by the manufacturer for adequate serviceability.

M. Operator Interface (Data Access Console) - The data access console shall be flush mounted in the door of the control panel. The console shall include an alphanumeric keypad with audible feedback. The following data shall be accessible through the operator interface:

1. One-touch access to display system status including flow rate (GPM), current system pressure and setpoint, the current speed of the pumps (in %), and the method of speed control.
2. Usage history shall record the maximum instantaneous flow, along with the date and time. Overall and current day totalized flow, pump starts, and pump run hours are also recorded. Usage history may be reset.

3. A Set Points Menu system for adjusting setpoints. Display and adjust flow and pressure set points and time delays. Restore to either factory defaults or the last saved field defaults. Protect adjustable settings with a password.

4. One-touch access to an Alarm History of the past 200 alarms. Each log shall include individual pump run status, system pressure and run setpoint, alarm type and the date and time.

5. One-touch access to an Alarm List of all possible alarms and their current status.

N. Variable Frequency Drives - Each pump shall have its own variable frequency drive with the following features:

1. The drive shall be a voltage source, GTR or IBGT power transistor based inverter - PWM Type. The inverter shall use a high carrier frequency to reduce drive and motor noise in a Nema-1 enclosure.

2. Drive shall be capable of operating in an ambient temperature between 15 degrees F and 100 degrees F and a line voltage variation of less than 10 percent. Self protection features shall include: under voltage and over voltage protection, current overload protection, short circuit protection, power failure protection, ground fault protection, and over-temperature protection. A four digit LED readout shall be provided to indicate the following: drive enabled, output frequency, and all VFD fault conditions.

O. The drive shall be capable of automatically restarting after any of the following: overload over-voltage, converter over-current, inverter over-current, or power failure.

P. The following drive parameters shall be user adjustable: acceleration speed (1 to 300 seconds), deceleration speed (1 to 300 seconds), minimum speed, and maximum speed.

Q. The drive shall have a front mounted "HAND-OFF-AUTO" selector switch and a potentiometer for adjusting drive speed in the "HAND" position.

R. Pressure Transmitters - A digital pressure transmitter shall be connected to the system header. The transmitter shall have 1.0% accuracy, stainless steel wetted parts and a waterproof enclosure. Transmitter shall be capable of withstanding over pressurization of double its range. The transmitter shall use a digital 1-6 kHz pulse output that can be directly sent to a programmable logic controller (PLC) without requiring an additional analog module for measuring current. The transmitter zero set point must be capable of field calibration.

S. Instrumentation - Each system shall have pressure gauges for indicating suction and system discharge pressure, pump run indicating lights, and control power light. All pump or header mounted pressure gauges shall be 4½" glycerin filled gauges. All panel mounted gauges shall be 2 1/2" glycerin filled gauges. Gauges shall have a stainless steel case and crimp ring, copper alloy movement with the case connection sealed with EPDM "O"-ring. Gauges shall be according to ASME B40.100, Grade A and shall have an accuracy of 1% of span.

T. Emergency Controls and Alarms **-** Furnish temperature relief valves at each pump, low suction, low system and high system pressure alarms, indication of first activated alarm, pulsing alarm horn with silence function, and individual alarm auxiliary contacts, time delays, and indicating lights.

U. Factory Prefabrication - The system shall be factory prefabricated. Furnish **flanged** schedule 40, 304SS suction and discharge headers for right hand connections. The only field connections required will be to system headers, tank, over-temperature drain tube, and one incoming power connection at the control panel. It is strongly recommended that a stainless steel flexible connector be installed between the suction and discharge headers and incoming building piping to accommodate any minor misalignment and dampen any excessive vibration.

V. All skid members must be properly designed structural steel members to adequately support the weight of the entire system and resist bending during transportation.

W. To minimize leak points, all branch and header connections shall be flanged or welded with the only threads located at the pump discharge. All pressure sensing lines shall be ¼", 304SS.

X. Factory Test and Certification - The booster system and its component parts shall undergo a complete operational flow test from zero to 100% design flow rate under the specified suction and net system pressure conditions. This flow test shall be performed by supplying the control panel with the specified incoming voltage. Each pump's performance shall be tested over its full range of flow. All adjustments shall be set and all functions verified. Components shall be tested for hydraulic shock, vibration, or excessive noise. Any parts found to be defective must be replaced prior to shipment. Full documentation shall be maintained by the manufacturer showing flow rates, pressures, and amp draws for future service and troubleshooting. In the Operation and Maintenance Manuals, include an X-Y graph of system pressure-flow performance, when required.

Y. Field Piping - The contractor shall install the system adjacent to a floor drain sized in accordance with local code. This drain is to prevent building damage in the event of seal failure and to receive over-temperature protection discharge. The contractor shall pipe the temperature relief valve discharge line to the drain. To reduce the possibility of damaging vibration, the contractor shall install the pump system on a flat housekeeping pad, bolted and grouted in place. The pump system shall be piped with a bypass and isolation valves, and with flexible connectors at the header connections.

Z. System Warranty - The complete pumping system shall be guaranteed in writing by the manufacturer for a period of one year from date of startup or eighteen months from shipment, whichever comes first, against defects in materials and workmanship. Warranties and guarantees by the suppliers of various components in lieu of single-source responsibility by the manufacturer will not be accepted.

2.3 FLEXIBLE CONNECTORS

A. Manufacturers:

1. Hyspan Precision Products, Inc.
2. Metraflex, Inc.
3. Unaflex Inc.

B. Description: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing. Include **150-psig (1035-kPa)** minimum working-pressure rating and ends according to the following:

1. Provide flanged connections.

2.4 BUILDING-AUTOMATION-SYSTEM INTERFACE

A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:

1. On-off status of each pump.
2. Alarm status.

PART 3 - EXAMINATION

3.1 EXAMINATION

A. Examine roughing-in for packaged booster pumps to verify actual locations of connections before booster pump installation.

3.2 CONCRETE BASES

A. Install concrete bases of dimensions indicated for packaged booster pumps. Refer to Division 15 Section "Basic Plumbing Materials and Methods."

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
4. Install anchor bolts to elevation required for proper attachment to supported equipment.

B. Cast-in-place concrete materials and placement requirements are specified in Division 3.

3.3 BOOSTER PUMP INSTALLATION

A. Install packaged booster pumps level on concrete bases with access for periodic maintenance including removal of pumps, motors, impellers, couplings, and accessories.

1. Do not dismantle packaged booster pumps or remove individual components.

B. Vibration Isolation: Install on spring isolators with minimum deflection. Vibration isolation devices are specified in Division 15 Section "Mechanical Vibration and Seismic Controls."

C. Support connected domestic water piping so weight of piping is not supported by packaged booster pumps.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Connect domestic water piping to packaged booster pumps. Install suction and discharge pipe equal to or greater than size of unit suction and discharge headers.

1. Install flexible connectors on piping connections to unit suction and discharge headers. Install flexible connectors same size as piping.
2. Install shutoff valves on piping connections to each booster pump suction and discharge headers. Install ball, butterfly, or gate valves same size as suction and discharge headers. General-duty valves are specified in Division 15 Section "Plumbing - Valves."
3. Install union or flanged connections on pump suction and discharge headers at connection to domestic water piping.
4. Install piping adjacent to packaged booster pumps to allow service and maintenance.

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform the following startup service:

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Check piping connections for tightness.

3. Clean strainers if any.
4. Verify that pump controls are correct for required application.

B. Perform the following startup checks for each pump of packaged booster pump unit before starting:

1. Verify bearing lubrication.
2. Prime pumps by opening suction valves and closing discharge valves, and prepare pumps for operation.
3. Start motors.
4. Open discharge valves slowly.
5. Adjust settings.

C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting packaged booster pumps to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.

3.6 LABELING AND IDENTIFICATION

A. Install identifying equipment markers and equipment signs on booster pumps. Labeling and identification materials are specified in Division 15 Section "Plumbing - Identification."

3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged booster pumps. Refer to Division 1 Section "Closeout Procedures" and/or "Demonstration and Training."

3.8 DUPLEX SUMP PUMP

A. SP-1 - Furnish a Duplex submersible 6" discharge non-clog pump system supplied by FTI Pumps and Controls of Elgin, IL. Each pump shall be capable of delivering USGPM.

B. The pumps shall be capable of passing **3" spherical solids** with double silicon carbide mechanical seals. The pumps shall include a quick disconnect guide rail system for removal of the pumps using a galvanized chain of adequate length. The guide rails shall be securely fastened to the chamber wall cover plate by the plumbing contractor.

C. Furnish Duplex Steel Hatch Type cover with all necessary openings for pump discharge, vent and control cables. Each pump shall be removable through the cover without disturbing the other pump.

D. Furnish a deep fiberglass basin with anti-floatation flange and (1) loose 6" inlet hub. Basin shall include stainless steel mounting studs glassed into the bottom for guide rail base installation.

3.9 EBARA STATION BOSS II CONTROL SYSTEM

A. The complete integrated pump and control system shall be a standard product of a single manufacturer. The control system shall be a completely integrated solid-state system specifically designed for the municipal and industrial markets. The complete pump control system shall be delivered to the customer with a UL Label indicating that the equipment has satisfied the requirements of the Underwriters Laboratory.

3.10 GENERAL SYSTEM OPERATION

A. Operation of the pumps shall be controlled by the direct manipulation of motor load. Speed control shall not be an acceptable alternative. All control of the pump station operations shall be completely integrated through a central processing PLC (Programmable Logic Controller) as described below, including the following:
   1. Level and/or Flow Measurement
   2. Alternation Set up screen
   3. Standard / Timed Alternation
   4. Standard / Staggered pump shutdown
   5. Ability to take a pump out of rotation (This will not allow the pump to be the lead pump, but will allow it to be called at other pump calls).
   6. VFD(s) pump control.
   7. Re-settable pump elapsed time meters.
   8. Re-settable pump cycle counters.
   9. Real time system status screen.
   10. Real time I/O diagnostics screen.
   11. Pump load status screen.
   12. Three levels of protection
   13. User (no password required)
   14. Level set points
   15. Alternation set up
   16. Basic system set up
   17. Technician 9level 1 password required)
   18. Load set up

B. The Pump and Controller Package shall be capable of assuring the following specific performance: Start up amps shall not be measurably greater than the full load amp rating of the Motor. The pump controller shall make possible **unlimited** number of start / stops per hour, thus minimizing danger of under sizing the wet well or short cycling the pumps. (No longer being held to the 18-20 starts per hour only). The pump controller package shall make possible safe over speeding of the pump motor in order to respond to occasional build up of air/sediment in the discharge piping. The pump controller package shall make possible a PID control of the pump and motor which will permit safe operation during runout conditions to pump heads of 10-15 feet TDH without exceeding the motor nameplate HP and without exceeding the full load amp rating of the Pump. The pump controller shall be capable of creating “Virtual” pumps. Shall be able to provide “Load Scaling”, “Load Linearization”, and “Load Balancing” Load Scaling: Be able to set Min / Max operating points for each pump (Up to 4). Load Linearization: Be able to Linearize the performance of the pump between the Min / Max operating points that have been set up. Load Balancing: Be able to take the Scaled Min / Max values and simultaneously operate equally to share the load.

C. Level Control: The controller shall provide a 4-20 milliamp for a customer supplied measurement level control. The control software shall provide the ability to scale the 4-20 milliamp to the range of the customer-supplied probe without the need of customer programming. The system shall be capable of inputting an offset in inches, if the transducer is not resting on the bottom of the wet well.

D. Flow Control: The controller shall provide a 4-20 milliamp for a customer supplied measurement of Flow for control if desired. The control software shall provide the ability to scale the 4-20 milliamp to the range of the customer-supplied Flow meter without the need of customer programming. The pump operation levels shall be settable through the HMI (Human Machine Interface). The pump operation levels shall be low-low redundant off, Low Level Off, First Pump Start, Second Pump Start, Third pump Start, Fourth pump Start and High Level Alarm. Once the parameters have been selected the PLC shall use these settings to operate the pumps. The control system shall be capable of either maintaining a set wet well level or maintaining a set system flow using independent PID routines as described below. The control system shall have a settable Level P.I.D. (Proportional Integral, Derivative) hold point. The P.I.D. hold point shall adjust the load input to the VFD's thereby maintaining a constant wet well level while simultaneously trimming the load setting to find the BEP (Best Efficiency Point) for the required flow rate. The control system shall have a settable Flow P.I.D. (Proportional Integral, Derivative) hold point. The P.I.D. hold point shall adjust the load input to the VFD's thereby maintaining a constant flow while simultaneously trimming the load setting to find the BEP (Best Efficiency Point) for the required flow rate. All system settings shall be retained during power fail and the system shall power back up and restart without any operator interjection.

E. Start-up: The pumps shall be tested at start-up by a qualified representative of the manufacturer. A start-up report as provided by the manufacturer shall be completed before final acceptance of the pumps. Equipment shall be supplied by FTI Pumps and Controls of Elgin, IL 847-488-9588

END OF SECTION 15444

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY (REFER TO SCHEDULE OR DETAIL ON DRAWINGS)

A. This Section includes the following fuel-fired water heaters:

1. Commercial, high-efficiency, gas water heaters.
2. Compression tanks.
3. Water heater accessories.

1.3 DEFINITIONS

A. LP Gas: Liquefied-petroleum fuel gas.

1.4 SUBMITTALS

A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Product Certificates: For each type of **commercial** water heater, signed by product manufacturer.

D. Manufacturer Seismic Qualification Certification: Submit certification that commercial water heaters, accessories, and components will withstand seismic forces defined in Division 15 Section "Plumbing - Vibration and Seismic Controls." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control test reports.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.

H. Warranty: Special warranty specified in this Section.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. ASME Compliance:

1. Where ASME-code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1

E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.6 COORDINATION

A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.7 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Structural failures including storage tank and supports.
b. Faulty operation of controls.
c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Period(s): From date of Substantial Completion:

a. Commercial, Gas Water Heaters:

1) Storage Tank: 1 year.
2) Controls and Other Components: 1 year.

b. Compression Tanks: **One** year.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, and are limited to, manufacturers specified.

2.2 COMMERCIAL, HIGH-EFFICIENCY, GAS WATER HEATERS

A. Commercial, High-Efficiency, Gas Water Heaters: Comply with ANSI Z21.10.3/CSA 4.3.

1. Manufacturers:

a. AERCO International.
b. Bradford White Corporation.
c. Laars Heating Systems; Waterpik Technologies, Inc.
d. Lochinvar Corporation.
e. Patterson-Kelley.
f. Rheem Water Heater Div.; Rheem Manufacturing Company.
g. Ruud Water Heater Div.; Rheem Manufacturing Company.
h. Smith, A. O. Water Products Company.
i. State Industries, Inc.

2. Description: Manufacturer's proprietary design to provide at least 99 percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.

3. Storage-Tank Construction: ASME-code steel with **150-psig (1035-kPa) psig (kPa)**> minimum working-pressure rating.

a. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.

1) NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1.
2) NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.

c. Lining: Glass complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.

4. Factory-Installed, Storage-Tank Appurtenances:

a. Anode Rod: Replaceable magnesium.

b. Dip Tube: Provide unless cold-water inlet is near bottom of tank.

c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.

d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.

e. Jacket: Steel with enameled finish.

f. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.

5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural-gas fuel.

6. Temperature Control: Adjustable thermostat.

7. Safety Controls: Automatic, high-temperature-limit and low-water cutoff devices or systems.

8. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.

9. Draft Hood: closed combustion

10. Capacity and Characteristics: See schedule on drawings.

11. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.

2.3 COMPRESSION TANKS (EXPANSION TANK)

A. Description: Steel, pressure-rated tank constructed with welded joints and factory-installed, butyl-rubber diaphragm. Include air precharge to minimum system-operating pressure at tank.

1. Manufacturers:

   a. AMTROL Inc.
   b. Armstrong Pumps, Inc.
   c. Smith, A. O.; Aqua-Air Div.
   d. State Industries, Inc.
   e. Taco, Inc.
   f. Watts Regulator Co.
   g. Wessels Co.
   h. ITT Bell & Gossett

2. Construction:

   a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
   b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
   c. Air-Charging Valve: Factory installed.

3. Capacity and Characteristics:

   a. Working-Pressure Rating: **100 psig (690 kPa)**
   b. Capacity Acceptable: 30 gal. minimum.
   c. Air Precharge Pressure: 50 psi.

2.4 WATER HEATER ACCESSORIES

A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.

B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.

C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.

D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.

   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

E. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.

   1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.

F. Water Heater Mounting Brackets: Water heater manufacturer's factory-fabricated steel bracket for wall mounting and capable of supporting water heater and water.

G. Drain Pans: Corrosion-resistant metal with raised edge. Provide dimensions not less than base of water heater and include drain outlet not less than NPS 3/4 (DN 20).

H. Piping Manifold Kits: Water heater manufacturer's factory-fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.

I. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.5 SOURCE QUALITY CONTROL

A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.

B. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

C. Prepare test reports.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

A. Install commercial water heaters on concrete bases.

1. Concrete base construction requirements are specified in Division 15 Section "Basic Mechanical Materials and Methods."

B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install seismic restraints for commercial water heaters. Anchor to substrate.

D. Install gas water heaters according to NFPA 54.

E. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.

F. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.

G. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.

H. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend commercial-water-heater, relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.

I. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 15 Section "Plumbing Specialties" for hose-end drain valves.

J. Install thermometer on inlet and outlet piping of water heaters. Refer to Division 15 Section "Meters and Gages" for thermometers.

K. Install pressure gage(s) on inlet and outlet piping of commercial, fuel-fired water heater piping. Refer to Division 15 Section "Plumbing - Meters and Gages" for pressure gages.

L. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 15 Section "Plumbing - Valves" for general-duty valves and to Division 15 Section "Plumbing - Meters and Gages" for thermometers.

M. Install piping-type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.

N. Fill water heaters with water.

O. Charge compression tanks with air.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 16 Section "Grounding and Bonding."

D. Connect wiring according to Division 16 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, confirm proper operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.4 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water heaters. Refer to Division 1 Section "Closeout Procedures” and/or “Demonstration and Training."

END OF SECTION 15486

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15500 - HEATING, VENTILATION & AIR CONDITIONING (PIPING)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All work associated with piping systems.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section. 15010 - Basic Mechanical Requirements.

C. Section. 15050 - Basic Materials, Methods and Requirements (Mechanical)

D. This section is a part of each Division 15000 Section.

E. Section 09900 - Painting

1.3 REFERENCES

A. ANSI/ASME B31.9 Building Services Piping.

1.4 QUALITY ASSURANCE

A. Installer. Company specializing in piping systems with five years minimum experience.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials for each service, and locations.

C. Submit manufacturers installation instructions under provision of Section 01300.

PART 2 - PRODUCTS

2.1 MATERIALS FOR PIPE AND FITTINGS

A. Pipe and fittings shall be fabricated per the following schedule:

SERVICE	SIZE	PIPE	FITTINGS
L.P. Steam (below 15 psi)	2-1/2" and under	Schedule 40, Seamless or ERW, ASTM-A53, Grade B	Malleable iron 150 lbs; cast iron 125 lbs; screwed or socket weld
See note	3"-10"	Schedule 40, Seamless or ERW	Schedule 40 weld end (butt weld)
	12"-24"	Standard weight (.375" wall) ASTM S-53, Seamless or ERW	Std. Wt. (.375" wall) welded (butt weld)
L.P. condensate return, drips and pumped discharge	2-1/2" and under	Sch. 80, Seamless	Iron class 150 lb. screwed or socket weld
	3"-10"	Sch. 40, Seamless	Sch. 40 weld end (butt weld)
	12"-24"	Std wt. (.375"wall), Seamless	St. wt. (.375" wall) weld end (butt weld)
Closed condenser, chilled, hot water, dual temp., and secondary water (up to 300 psi) - mains, risers, vents and reliefs	3 " and under	Schedule 40 ASTM-A53, Grade B, Seamless or ERW	150 psi and under, malleable iron 150 lb., screwed 151 psi-300 psi: Malleable iron 300 lb. screwed
	3"-10"	Schedule 40, Seamless or ERW	Sch. 40 weld end
	12"-24"	Standard weight (.375" wall) , Seamless or ERW	Std. Wt. (.375: wall) weld end
Secondary water branches risers to shut-off valves	3 " and under	Schedule 80, Seamless or ERW from main/risers to valves to units/equipment	150 psi and under: Malleable iron 150 lb. screwed 151 psi – 300 psi: Malleable iron 300 lb screwed
	3"-10"	Schedule 80, Seamless or ERW	Sch. 80 weld end
	4" and under	OPTION: (from valves to units – equipment): copper type 'L' hard ASTM-B88 drawn, provide – dielectric fitting between steel/valve and copper pipe	Wrought or copper, brazed (B cup-5) ASTM-B32, ANSI B16.22
	12"-145:	Standard weight (.375" wall) , Seamless or ERW	St. wt. (.375" wall) weld end

SERVICE	SIZE	PIPE	FITTINGS
Drain Pan Piping See Note 2	4" and under	Copper Type L hard drawn	Wrought or copper with lead free 95/5 solder or brazed
Domestic Water	3" and under	Copper Type L hard drawn	Wrought or copper with lead free 95/5 solder or brazed.
Vents and Reliefs		Same materials as pipe systems they serve	Same material and fittings as systems they serve.
High Temperature Hot Water	3" and under	Schedule 80 ASTM A-106 Grade B seamless	Malleable iron, 300 lb. class screwed or socket weld 300 lbs.
	3"-10"	Schedule 40, Seamless	Sch. 40 weld end (butt weld)
	12"-24"	Standard weight (.375" wall) Seamless	Std. Wt. (.375" wall) weld end (butt weld)
Fuel Oil Piping See “Fuel Oil Systems”			
Refrigerant Piping See “Section 15530"			
MRI Vent Piping		Aluminum piping (0.500 in wall thickness)	

NOTES

1. Unless specified otherwise, all steel piping shall be Type ASTM-A-53 Grade B seamless or ERW. Furnace butt weld pipe is not acceptable. All pipe shall be of the domestic manufacture, delivered to the job properly primed and marked and supplied with the interior surfaces clean and rust free. Each end shall be capped to avoid the rusting of the interior surface. Piping found to be in violation of this specification may be required to be removed from the job site whether or not already installed. Mill certifications from the pipe supplier shall be made available upon request.

2. All copper tubing shall be not less than 99.9 percent pure copper, as manufactured by Revere Copper and Brass Co., Chase Brass and Copper Co., Inc. Bridgeport Brass Co., or other approved. Wherever possible, tubing shall be continuous with couplings up to 20 feet in length. Tubing shall conform to ASTM B88.

3. ASME B31.1 Power Piping Code shall apply for all steam condensate systems over 150 psi @ 366°F (and or Local Jurisdictional Codes) and for high temperature hot water systems above 160 psi and 250°F.

B. Piping specifications shall be submitted with shop drawings.

C. All pipe fittings shall be of domestic manufacture in conformance with the following codes:

Cast iron fittings	ANSI B16.4
Malleable iron fittings	ANSI B16-3
Weld end fittings	ANSI B16-9, ASTM A-234
Socket weld fittings	ANSI B16.11
Copper fittings	ASTM B-32, ANSI B16.22
Welded flanges	ASTM-A105; ANSI B16.5
Cast copper	B16.18
Threaded Flanges	
Cast Iron	ANSI B16.1
Malleable Iron	ASTM A197
Malleable Iron Unions	ASME B16.39

D. Open condenser water systems are defined as systems in which the atmosphere is in direct contact with water in piping system via an open cooling tower.

E. Galvanized steel pipe shall be hot dipped galvanized of Republic Steel Corporation, National Tube Co., Youngstown, or other approved manufacturer.

F. Secondary water branches shall be shop fabricated. Steel branches shall be shop fabricated complete with valve and accessory fittings and suitable for welding to risers without further work. Copper branches similarly shall be shop fabricated with all accessories suitable for ready attachment to unit and steel branches. Provide a dielectric fitting between steel and copper pipe (a brass valve is not a substitute for a dielectric fitting).

G. On 3" piping systems, the contractor shall have the option of using either screwed or weld end fittings unless otherwise noted in the Contract Documents, directed and/or compliance to local jurisdictional codes or authorities.

2.2 VALVES

A. Furnish and install valves shown on the drawings, specified herein and/or necessary for the control and easy maintenance of all piping and equipment. All valves shall be first quality of approved manufacture, shall have proper clearances, and shall be tight at the specified test pressure. Each valve shall have the maker's name or brand, the figure or list number and guaranteed ANSI working pressure cast on the body and cast or stamped on the bonnet, or shall be provided with other means of easy identification. All valves of one type (gate, ball, butterfly) shall be the product of one manufacturer for that type of valve.

B. Valves shall be a minimum working pressure and materials as fittings specified for the service except as herein modified. All gate and globe valves shall be suitable for repacking under pressure. Regardless of service, valves shall not be designated for less than 125 pounds per square inch steam working pressure.

C. It is the intention to use ball and butterfly valves for shut-off wherever possible. Gate valves shall be used for steam systems where ball and butterfly valves may not be practical by pressure/temperature or local authority having jurisdiction.

D. The following chart designates valve categories for shut-off valves:

SHUT OFF VALVE SCHEDULE

	CATEGORY	SIZE	TYPE	MFG. AS STD.	FIG. #	RATING
V-1	Up to 150 psi CW, CHW, HW	2 ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-100 815L-11-2236TT	600# WOG ANSI 150#
V-2	151-300 psi CW, CHW, HW	2/ ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-100 830L-11-22HMBT	600# WOG ANSI 300#
V-3	Steam & Condensate Up to 15 psi	2 ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-140-64 815L-11-22HBTT	250 psi STM ANSI 150#
V-4	Steam & Condensate (Non Utility Company Steam) 16 psi - 125 psi & High Temp Hot Water up to 300°F	2 ½" & down 3" & up	Ball Butterfly	Apollo Jamesbury	70-140-64 830L-11-22HBMT	250 psi ANSI 300#

NOTES:

SHUT OFF VALVE EQUIVALENT FIGURE SCHEDULE

VALVE TYPE	SERVICE	ANSI RATING	MAX. WORKING PRESSURE @ 200°F	MODEL
Ball	CW, CHW, HW		300 psi	Apollo 70-100 Milwaukee BA-100
Butterfly	CW, CHW. HW	150		Bray/McCannalock Series 41 (Lug Type) Keystone Series 372 DES (Lug Type) Winn S15L-1122 (Lug Type)
Butterfly (See Note)	CW, CHW, HW	300		Bray/McCannalock Series 43 (Lug Type) Keystone Series 372-DES (Lug Type) Winn S30L-1122 (Lug Type)

VALVE TYPE	SERVICE	ANSI RATING	MAX. WORKING PRESSURE @ 200°F	MODEL
Gate	up to 2-½" Steam		150#	Stockham Figure No. B-120 Powell Figure No. 2700 Milwaukee Figure No. 1151
	3" & up Steam		150#	Stockham Figure No. G623 Powell Figure No. 1793 Milwaukee Figure No. F-2885M
	up to 2-1/2" Steam and Utility Company Steam		300#	Stockham Figure No. B-144 Powell Figure No. 375 Milwaukee Figure No. 1182
	3" & up Steam and Utility Company Steam		300#	Stockham Figure No. F-667 Powell Figure No. 1797 Milwaukee Figure No. F-2894M

NOTES:

1. Butterfly valves shall have gear operator 8" diameter and larger for ANSI 150 valves; 6" and larger for ANSI 300 valves. Valves smaller shall have multi-position latching handle.

2. Valves 4" and larger (all valve sizes for steam over 15 psig) in equipment area which is more than 8'-0" above finished floor shall be provided with operating chains, sprockets, and guides.

3. All ball valves shall have the following options:

   a. Balancing stop for hydronic installations.

   b. 2 1/4" stem extensions on insulated piping systems.

   c. Stainless steel ball and stem, and multi-filled TFE seats for steam, condensate and high temperature hot water systems.

4. Valves for Con Edison Steam shall comply with Con Edison specifications.

5. Gate valves shall be Stockham, Powell or Milwaukee.

   a. Bronze valves 3" or smaller shall be inside screw, traveling stem, bronze wedge.

   b. Iron body valves 3" and above shall be outside screw and yoke, rising stem, bronze mounted.

6. Butterfly valves shall be high performance lug type Jamesbury, McCannalok, Grinnell Winn Series or Keystone 362/372 DES series. Valves shall be bi-directional dead end service, lug type ANSI Class 150 or 300.

   a. The face-to-face dimensions must meet AP Spec I609 MSS SP 67.

   b . Pressure vessel is to meet full ANSI ratings.

   c. Valve is to seal bi-directional dead end service at full ANSI ratings. Valve shall hold full pressure with either flanged connection removed, in either direction.

   d. Valves are to be able to take full rated differential pressure when dead-ended in either direction.

   e. Valves shall have gear operator 8" and larger for ANSI 150 valves, and 6" and larger for ANSI 300 valves. Valves smaller shall have multi-positioned latching handle.

   f. All valves shall be designed to ANSI B16.5 and B16.34.

   g. All valves to be functionally tested, to include cycling the valve and topworks, measuring seating torque and verifying leaktight performance of seat.

   h. The valve should be capable of thermal cycling over its complete pressure vessel rating.

   I. The shaft packing must be capable of sealing at 1.5 times the pressure vessel rating.

   j. The valve should be designed to convert from handle operation to automated valve operation without removing the valve from the pipeline.

   k. There must be external indication of disc position.

   l. Valve stem packing area shall be fully accessible for adjustment without removal of operator.'

   m. If manually operated, the valve must have a positively retained shaft in case there is a failure of the shaft to disc attachment.

   n. Self-lubricated bearings should be used. There will be a method of retention to prevent bearing movement.

   o. No loose parts should be used to attach the shaft to the disc. Two or more pins should be used for complete attachment.

   p. A double offset shaft should be used to reduce seating torque.

   q. Valves body material shall be carbon steel. Shafts shall be 17-4 PH stainless steel. Discs shall be 316 stainless steel. Stem seals shall be TFE. Seats shall be self-energizing TFE or self-energizing TFE totally encapsulating as elastomeric "O" ring. Metal springs or components shall not be used to and in seat sealing.

   r. Seats shall be fully replaceable in the field.

s. Ductile iron body may be used for chilled water and condenser water service, at 150 psi max service. All other valve components shall be as specified.

E. Lubricated plug valves at pump discharges shall be Nordstrom Valves, Inc. (Rockwell), Homestead or Stockham as follows:

CATEGORY	SIZE	FIGURE NO.	RATING
Up to 150 psi operating pressure	Up to 3"	142 wrench operated (screw)	200# cwp (190° # @ 200°F)
	3"-5"	143 wrench operated (screw)	200# cwp (190# @ 200°F)
	6"-12"	1169 worm gear operated (flgd)	200# cwp (190# @ 200°F)
	14"-30"	1169 worm gear operated (flgd)	150# cwp (135# @ 200°F)
151 psi to 300 psi	1"-2"	214 wrench operated (screw)	400# cwp @ 150° @ 250F)
	2"-5"	305 wrench operated (flgd)	400# cwp @ 150° @ 250F)
	6"-12"	1489 worm gear operated (flgd)	400# cwp @ 150° @ 250F)
	16"-24"	1589 worm gear operated (flgd)	400# cwp @ 150° @ 250F) (See Note 2)

NOTES:

1. Use Figure No. 1589 for systems with operating pressures greater than 135 psi at water temperature above 150°F.

2. Use with ANSI 300# flanges.

3. For hot water systems above 200°F, use valves listed for 151-300 psi operating pressures.

4. Lubricated plug.

5. Sealed port lubrication system.

6. Provide lubrication gun and spare box of lubricant for every four (4) valves.

7. Fixed gland adjustment when valve rating is 200 lb. WOG or higher to suit actual operating pressures.

8. Equipped with adjustable stops.

9. Factory lubricated.

10. Provide chain wheel drive and operator for valves 6" and larger that are located 96" or higher above floor.

F. Equivalent Lubricated Plug Valves

PSI	SIZE	MFG	FIGURE NO.	OPERATION
Up to 150 psi	Up to 3"	Walworth Homestead	1796 (screw) 611 (screw)	Wrench Wrench
	3" to 5"	Walworth Homstead	1797F (flange) 612	Wrench Wrench
	6" to 12"	Walworth Homestead	1707 612G	Worm Gear Operation Worm Gear Operation
	14"to 24"	Walworth Homestead	1703F 6129	Worm Gear Operation 175 CWP Worm Gear 150 CWP
151 to 300 psi	Up to 3"	Walworth Homestead	3412 702	Wrench ANSI 300
	6"-12"	Walworth Homestead	3622 721G	Worm Gear ANSI 300 Worm Gear Operation
	14"-24"	Walworth	3622	Worm Gear Operation

G. Check valves other than multiport check valves at pumps shall be Stockham, Powell or approved equal. Bronze screwed for 2-1/2" and down with regrinding bronze disc and iron body above 3" with regrind - renew bronze disc, and seat ring with bolted cover. Pressure ratings equal or greater than ratings of shutoff valves scheduled.

Category	Size	MFG	Figure No.	Rating
V-1	Up to 2-1/2"	Powell Stockham Milwaukee	578 B321 509	Up to 150 PSI operating pressure
	3"	Powell Stockham Milwaukee	559 G-931 F-2974M	
V-2	Up to 2-1/2"	Powell Stockham Milwaukee	560-1 B-345 508	151 to 300 PSI

Category	Size	MFG	Figure No.	Rating
	3" and larger	Powell Stockham Milwaukee	576 F-947 F-2970	

H. Multiport check valves at pump discharge shall be semi-steel installed at pump discharge as follows:

Cat.	Size	MFG	Figure No.	Rating
V-1	Up to 3"	Mueller	101 MAP Wafer	125# ANSI (175@100ºF)
	4" and larger	Mueller	105 MAP Globe Type	125# ANSI (200#@150ºF)
V-2	Up to 3"	Mueller	103 MAP Standard Wafer	250#ANSI (500#@150ºF)
	4" and over	Mueller	M 107 MAP Globe Type	250# ANSI (500#@100ºF)

NOTE

1. For system pressures over 250 psi use 300# ANSI from 14" to 24" bronze body (300# PSI at 150°F).

I. Balancing Valves:

1. Balancing valves shall be ball type for 2-1/2" and down, lubricated plug valves for above 3", and shall be full line size. At cooling towers use butterfly valves.

2. Furnish and install in the return line from each piece of hydronic equipment (cabinet heaters, unit ventilators, unit heaters, fin tube, water coil, hydronic terminal equipment, etc.) a one piece, non-ferrous union type bronze/brass flow measuring and Balancing/shut-off valve combination. The flow element shall be a low loss/high signal Venturi type (± 2% accuracy) of one to ten rangeability, equipped with dual Pete's plug test ports for temperature, pressure and flow measurement. Balancing/shut off valves shall be ball type with large diameter plated ball, teflon seats, blow out proof stem with teflon packing and packing nut, full size handle with grip and memory stop. Entire assembly shall be rated to working pressures described in previous section of this specification.

J. Miscellaneous Notes:

1. Furnish valve tags as described elsewhere.

2. All radiators, hydronic equipment, etc., shall be individually valved on supply and return.

3. Furnish a portable meter complete with all accessories for measuring flows.

4. Furnish to the Owner, 6 sets of thermometers and pressure gauges.

5. On branch piping from hydronic main distribution piping (branch piping is defined as any piping from either main distribution piping that serves more than one piece of hydronic equipment) or branch piping form main distribution piping to vertical risers, provide an isolation valve on supply line and combination balancing and shut-off valve on return line.
6. Globe valves be of equivalent pressure ratings and manufacturer to that stated for gate valves.

7. Chilled water piping connections to air conditioning units shall include all necessary gate valves, air vent valves, drain connections and automatic valves.

8. Inverted ball float traps shall be used for venting water mains. Provide shut-off valve and strainer ahead of same.

9. Compression type, key operated air cocks shall be furnished and installed where required for additional venting. Cocks shall be 1/4" in size and shall be all bronze construction, at least two dozen keys shall be delivered to the Owner's representative for operating these cocks.

10. Drain cocks with threaded ends for hose connection shall be provided for any low points in the risers.

2.3 STRAINERS

A. There shall be approved strainers in the inlet connections to each bucket or combination float and thermostatic steam trap, each water feeder and make-up connection, each water regulating valve, each pump, each vent, and each diaphragm valve. The intention is to protect by strainers, all apparatus of an automatic character whose proper functioning would be interfered with by dirt on that seat, or by scoring of the seat. Strainers shall be Sarco or approved.

B. All strainers in waterlines (including all pump inlets) and in steam lines, shall be Y-pattern, set in a horizontal (or vertical downward) run of the pipe. Where this is not feasible strainers may be of enlarged-cross-section type. Strainers shall be so arranged as not to "trap" pipes, and to facilitate disconnection and opening-up for cleaning. Unless otherwise indicated, strainers shall be line size.

C. All strainers shall have cast iron, semi-steel or bronze bodies equivalent to ratings specified in "valves" subjected, removable cylindrical or conical screens of monel or stainless steel and suitable flanges or tappings to connect with the piping they serve. They shall be of such a design as to allow blowing out of accumulated dirt, and to facilitate removal and replacement of a strainer screen, without disconnections of the main piping.

D. Strainer screen perforations shall be 1/32" for steam and mixture of steam and condensate. Water 1/16" perforations for sizes up to 3"; 1/8" perforations for sizes 4" to 12".

E. Provide approved valved and capped dirt blow off connections for each strainer 1-1/2" and larger, with the valve located 6" to 1'-0" below strainer or as directed.

F. Nipples and valves to be full size of strainer blow off tapping. Strainers 1¼" and smaller to have capped nipples at least 6" long. For all strainers, the blow out connection is to terminate in an approved manner, at a point where there will be no risk of flooding or damage.

G. All strainers shall be provided with flanged covers for screen removal in lieu of screwed covers for screen removal wherever obtainable.

H. All strainer screens 8" and above shall be reinforced for the operating conditions.

2.4 EXPANSION JOINTS & LOOPS

A. All piping shall be installed in such a manner as to allow for expansion and contraction by means of offsets, pipe loops or expansion joints without causing undue stress in piping or at connections to equipment. Where pipe offsets or loops are not detailed or dimensioned on drawings, the contractor is to submit calculations to show that the stress range of the pipe does not exceed 15000 psi.

B. Expansion joints shall be the type, manufacturer and model number as indicated on drawings. Where no type or model number is indicated, any of the expansion joints described below may be used if they are suitable for design and operating conditions of temperature pressure and movement except that Bellow Expansion Joints and Expansion Compensators shall not be used for (a) steam with pressures over 15 psig for all sizes or (b) hydronic systems operating over 200 psig operating pressure in all sizes.

C. All expansion joints shall be designed so that pressure containing components are in accordance with requirements as specified in ANSI B-31.1 Power Piping.

D. All expansion joints and expansion compensators shall have a metal nameplate permanently attached bearing inscription of size, type, pressure rating, allowable movement, year of fabrication and manufacturers identification number.

E. All pipe lines containing expansion joints shall be guided in accordance with expansion joint manufacturers instructions as substantiated by data in manufacturers catalog or separate date furnished with submittal drawings.

F. Contractor, in conjunction with information provided by expansion joint manufacturer is to submit anchor load calculations for both operating and hydrostatic test conditions.

G. Packed Slip Expansion Joints:

1. Packed slip expansion joints shall be weld end type designed for the injection of semi-plastic packing under full line pressure and shall be the manufacturer and model number indicated on drawings incorporating following:

(a) Sliding slip shall be constructed of A53 Gr B seamless pipe - schedule 80 for sizes to 16" inclusive and schedule 60 for sizes 18" to 24" and shall incorporate stainless steel stops welded in place to prevent disengagement of slip in event of anchor failure. Slip shall be dual chrome plated with a minimum of 1 mil hard chrome over 1 mil of crack free hard chrome. Plating thickness shall be verified by

Permascope inspection in accordance with ASTM Standard B-499 and certification shall be furnished with expansion joint.

(b) Traverse chamber shall be seamless A-53 Grade B pipe or equivalent tubing with butt type circumferential welds only and shall be furnished with non-metallic flexible bronze filled teflon internal and external guides to prevent scoring or binding of sliding slip.

(c) Stuffing box shall be designed to provide an area of packing in contact with the sliding slip at least 15 times the nominal pipe diameter and shall incorporate one (1) packing cylinder for 1-1/2" thru 4" size and one (1) additional cylinder for each 3" of nominal pipe diameter. Packing cylinders shall be welded in place, be a minimum 2" diameter with internal acme threads with a discharge tip having a check valve effect to prevent blow back and permit adding packing under full line pressure and furnished with a matching plunger having a minimum 3/4" diameter tip. Expansion joints operating over 200 psig shall be furnished with packing cylinders having an integral stainless steel plug type safety valve for positive blow back protection.

(d) Stuffing box shall be packed with a combination of self lubricating teflon/graphite braided packing and flake Grafoil injectable packing. Teflon-asbestos and teflon semi-plastic injectable packings are not acceptable and shall not be used.

(e) Each expansion joint shall be furnished with a minimum of two (2) plugs of spare flake Grafoil semiplastic injectable packing for each packing cylinder. For system operating over 200 psig where expansion joints are furnished with packing cylinders having an integral stainless steel plug type safety valve, a tools shall be furnished to safely remove under full line pressure the impacted packing between safety valve and discharge tip. Where project contains more than one (1) expansion joint operating above 200 psig, a minimum of one (1) such tools shall be furnished for every five (5) expansion joints operating above 200 psig.

(f) Expansion joints shall be as manufactured by Advanced Thermal Systems and shall be Type TP2W GBZ for 150 psig design condition and TP2W-131-150 GBBZ with Style GB Saf-T-Packer for over 150 psig design conditions. For expansion joints operating below 200°F, Style 200G packing with rubber and fiberglas sealing rings shall be used in lieu of Style 150 packing. Expansion joints as manufactured by Adsco and Yarway will be approved if they conform to all features specified above.

(g) Packed joints used for steam over 15 psig shall be 100% radiographed at factory.

2. Expansion joints shall be designed to accommodate an amount of traverse as shown in expansion joint designation as indicated on drawings or a total traverse greater than the combined extension and compression that must be accommodated after the expansion joint is installed including allowance for frame shortening in buildings with concrete columns. Submittal drawings

are to indicate amount of factory precompression as well as available movement in compression and extension from the installed position.

H. Packed Flexible Ball Joints:

1. Packed flexible ball joints shall be weld and type designed for injection of semi-plastic packing under full line pressure and shall be the manufacturer and model number indicated on drawings incorporating the features indicated below:

(a) Ball sphere shall be dual chrome plated with a minimum of 1 mil hard chrome over 1 mil of crack free hard chrome. Plating thickness shall be verified by Permascope inspection in accordance with ASTM Standard B-499 and certification shall be furnished with expansion joint.

(b) Ball socket shall be one piece with integral socket/retainer to eliminate the need for threaded caps or bolted retainer flanges.

(c) Ball socket shall incorporate packing cylinders in quantities as indicated below. Packing cylinder shall be welded in place, be a minimum of 2" in diameter with internal acme threads with a discharge tip having a check valve effect to prevent blow back and permit adding packing under full line pressure all furnished with a matching plunger having a 3/4" diameter tip. Expansion joints operating over 200 psig shall be furnished with packing cylinders having an integral stainless steel plug type safety valve for positive blow back protection.

Ball Joint Size	Qty. Parking Cylinders
3/4" to 4"	1
5" & 6"	2
8" & 10"	3
12" to 18"	4
18" to 20"	6
24"	8
30"	12

(d) Stuffing box shall contain compression seals of ductile iron, teflon-graphite containment seals and flake Grafoil injectable packing. Teflon-asbestos and teflon semi-plastic injectable packings are not acceptable and shall not be used.

(e) Each expansion joint shall be furnished with a minimum of two (2) plugs of spare flacke Grafoil semiplastic injectable packing for each packing cylinder. For system operating over 200 psig where expansion joints are furnished with packing cylinders having an integral stainless steel plug type safety valve, a tools shall be furnished to safely remove under full line pressure the impacted

packing between safety valve and discharge tip. Where project contains more than one (1) expansion joint operating above 200 psig, a minimum of one (1) such tools shall be furnished for every five (5) expansion joints operating above 200 psig.

(f) Expansion joints shall be as manufactured by Advanced Thermal Systems and shall be Type P2-SWW up to 150 psig or Type P2-SWW-150G-70-20B with Style GB Saf-T-Packer for systems operating above 150 psig. Packed flexible ball joint manufacturer to submit calculations verifying that length of spool piece between ball joints is ample to properly accommodate expansion and contracting including allowance for frame shortening in buildings with concrete columns.

2. Packed flexible ball joint manufacturer to submit calculations verifying that length of spool piece between ball joints is ample to properly accommodate expansion and contraction including allowance for frame shortening in buildings with concrete columns.

I. Bellows Expansion Joints and Expansion Compensators:

1. Bellow expansion joints and expansion compensators shall be the type, manufacturer and model number indicated on drawings and shall incorporate the following:

(a) Expansion joints in sizes 3" and over shall consist of Inconel 600 bellows formed from seamless tubing or tubing with longitudinal seam weld no greater than 10% thicker than parent material with flanged ends suitable for operating pressure and temperature.

(b) Bellows elements 3" and over may be externally pressurized or internally pressurized with supplemental reinforcing by means of external rings, if necessary. Internally pressurized bellows with three (3) or more corrugations shall be furnished with internal sleeves or liners. Bellows elements shall be designed in accordance with standards of the Expansion Joint Manufacturers Association (EJMA) for 7000 full cycles, unless otherwise indicated and calculations in accordance with EJMA standards are to be furnished with submitted drawings.

(c) Expansion joints in sizes 2-1/2" or less shall be "Expansion Compensator" type with externally pressurized bellows. For use with steel pipe, bellows shall be Inconel 600 and casing and threaded nipple ends shall be carbon steel. For use with bronze pipe or copper tubing, compensator casing and bellows shall be all bronze construction with threaded or sweat type ends. Expansion compensators shall be capable of accommodating 1-3/4" compression and 1/4" extension and shall be so placed in system that movements do not exceed these limits.

2. Expansion joints shall be designed to accommodate an amount of traverse greater than the combined extension and compression that must be accommodated after the expansion joint is installed including allowance for frame shortening in building with concrete columns. Submittal drawings are

to indicate amount of factory precompression as well as available movement in compression and extension from installed position.

2.5 HANGERS, SUPPORTS, ANCHORS, AND GUIDES

A. See "Seismic Design" and comply as follows:

1. See "Foundations, Vibration Isolation, and Supports for Rigidly Supported Equipment (Seismic Design)."

2. As noted in "Seismic Design", the HVAC contractor shall engage the services of a professional engineer with experience in the field of equipment support and seismic restraints (or an approved piping expert who has specialized in piping design). The Engineer shall select and coordinate the restraints and supports based on the final coordinated drawings showing exact location of piping and equipment and shall coordinate with the structural engineer to ascertain that the connections to the structure will resist the horizontal forces to which they might be subjected. He shall submit details and calculations as required to demonstrate compliance.

3. Seismic Restraints shall be installed to restrain and protect piping in the event of an earthquake and shall be installed in addition to pipe hangers, brackets and supports. Seismic Restraints shall not be used in lieu of regular hangers and supports as are otherwise required to support the piping.

4. Anchors shall be designed to accommodate seismic forces plus any forces imposed by expansion joints or pipe bends and loops. Loads and details of attachment to structure shall be submitted to structural engineer for coordination and approval.

B. In all cases, attachments to structure shall be approved by the Structural Engineer. Loads and details of attachment to structure shall be submitted to structural engineer for coordination and approval.

C. All required supports, hangers, anchors, and guides shall be provided and installed by this contractor. Shop drawings shall be submitted indicating the following.

1. Riser anchors shall not be fixed to building until floors are poured, due to possible settling.

2. Methods of hanging or supporting all mechanical equipment & piping furnished by this trade.

3. Insert locations intended for the hanging of any mechanical equipment shall note the weight to be hung from each insert.

4. Insert locations intended for the hanging of piping over 5" or equipment shall also note the weight to be hung from each typical insert.

5. Where other methods are used, beam clamps or fish plates, for example, weights shall be similarly shown.

6. Multiple piping whether by other trades or not, if included on a trapeze type hanger furnished by this trade shall similarly indicate weights.

7. Note that mechanical equipment is not limited to pipe connected equipment, but includes fans, coils, etc.

8. Although piping under 6" need not be shown, furnish information upon request at any time during the course of the installation.

9. The indication of weights will not be waived unless there is reason to accept a general statement, approved in writing by the Architect and/or the Structural Engineer.

10. The structural engineer must approve the method of hanging before work is commenced.

D. All pipe supports shall be of type and arrangement as shown on "Pipe Hanger and Support Schedule" on drawings and hereinafter specified. They shall be so arranged as to prevent excessive deflection and avoid excessive bending stresses between supports.

E. All bracket clamp and rod sizes indicated in this specification are minimum sizes only. This trade shall be responsible for structural integrity of all supports. All structural hanging materials except variable spring units shall have a safety factor of 5 built in.

Pipe Hanger Schedule			
	C&P	F&M	Grinnell
Beam Clamp	268	282	--
Clevis Hanger	100	239	260
Clevis Roller Hanger	140	272	181
Welded Steel Bracket	84	151 or 155	195 or 199
Welded Beam Attachment	113A	–	66
Insert	266	–	280
Continuous Slotted Insert	1480	190	--
Metal Deck Ceiling Bolt	143		

F. Pipe supports shall be of the following type and figure number, as manufactured by C & P, F & M, Grinnell or as approved, and as hereinafter indicated:

Pipe Hanger Schedule			
	C&P	F&M	Grinnell
180 Shield	265P	–	–
Beam Clamp	268	282	--
Clevis Hanger	100	239	260
120 Shield	265P	80	--
Pipe Saddle	354 355 356	170 & 1700 Series	180 Series
Clevis Roller Hanger	140	272	181
Two Rod Roller Hanger	142	170	171
Rigid Trapeze	371	–	Std. 45
U-Bolt	283	176	137
C.I. Roll Stand	17	160	271
Adj. C.I. Roll Stand	53	161	274
Adj. Steel Pipe Stanchion	101	291	259
Welded Steel Bracket	84	151 or 155	195 or 199
Single Bolt Riser Clamp	126	241	261
Double Bolt Riser Clamp	126	–	Std. 40
Base Elbow Support	375	–	–

Pipe Hanger Schedule			
Double Bolt Pipe Clamp	304	261	295
Welded Beam Attachment	113A	–	66
Welded Beam Attachment W/B&N	113B	251	66
Insert	266	–	280
Continuous Slotted Insert	1480	190	--
Metal Deck Ceiling Bolt	143		

G. Anchor points as shown on drawings or as required shall be located and constructed to permit the piping system to take up its expansion and contraction freely in opposite directions away from the anchored points.

H. Guide points for expansion joints shall be located and constructed wherever required or shown on drawings and at each side of an expansion joint or loop, to permit only free axial movement in piping systems but first guides shall not be further than 3 pipe diameters on each side of joint and second guides (and subsequent guides) shall be placed no further than 17 pipe diameters along length of pipe. Guides for pipe with expansion joints shall be of the four roller heavy duty type securely welded to structural steel.

I. Guides shall be of sufficient length to contain a pipe movement 30% greater than actual pipe movement.

J. Variable spring hangers shall be located and constructed for points subject to vertical movement.

K. Maximum spacing between pipe supports, for steel pipe to prevent excessive stress: This does not apply where there are concentrated loads between supports.

Pipe Size	Max. Span/Ft.	Pipe Size	Max. Span/Ft.
1/2"	5	4"	14
3/4"	6	5"	16
1"	7	6"	17
1½	9	8"	19
2"	10	10"	22
2½”	11	12" over	23
3"	12		

L. Maximum weights on hanger rods assuming a maximum operating temperature of 450°F shall be such that stress in tension shall not exceed 9000 psi, using root area of threaded portion. In no case shall hanger size be less than 3/8" for pipe up to 2", 1/2" for pipe 2-1/2" to 3-1/2", 5/8" for pipe 4" to 5", 3/4" for pipe 6", 7/8" for pipe 8" to 12".

M. Double bolt riser clamps shall be F&S, F&M, Grinnell or approved and shall be subject to approval.

N. Back to back channel loads shall be limited to the following:

1. 3" (4.1#) channel - 2900 lbs up to 36" C To C.
2. 3" (4.1#) channel - 1700 lbs over 36" C To C.
3. 4" (5.4#) channel - 5100 lbs up to 36" C To C.
4. 4" (5.4#) channel - 3000 lbs over 36" C To C.

O. Pipe stanchion supports for horizontal pipes shall be as follows:

Run Size	Base
2½" to 3½	2½"
4" to 12"	3"
14" to 16"	4"
18" to 36"	6"

P. Pipe supports at the base of a vertical riser shall be pipe riser size.

Q. For copper tubing, supports shall follow schedule and specifications. Supports for uncovered lines shall be especially designed for copper tubing, and shall be of exact O.D. diameter of tubing and shall be copper plated.

R. Roller type supports shall be used for pipes subject to axial movement. They shall be braced so that movement occurs in roller rather than support rods.

S. Provide shields at hangers for cold insulated piping and saddles welded to pipe at hangers for hot insulated piping.

T. Provide all steel required for support of pipes and equipment other than steel shown on structural engineer's drawings. Submit calculations of anchor design.

U. All hangers on piping including clevis hangers, rods, inserts, clamps, stanchions, brackets, shall be dipped in Zinc Chromate Primer before installation.

V. All pipe supports shall be designed to avoid interferences with other piping, hangers, electrical conduits and supports, building structures and equipment.

W. Pipe hangers shall be connected to building structure as follows:

Building Structure Type	Pipe Support Method
Poured concrete floor slabs.	Galvanized steel inserts and/or fishplates of sufficient area to support twice the calculated dead load.
Building Structure Steel.	Beam Attachments, etc.

Building Structure Type	Pipe Support Method
Precast concrete floor slabs.	Fishplates of sufficient area to support twice the calculated dead load, approved type specialty hanger accessories manufactured for the specific purpose of attaching to precast floors.
Metal deck floor slabs with concrete fill.	Galvanized steel inserts, fishplates of sufficient area to support twice the calculated dead load, approved type specialty hanger accessories manufactured for the specific purpose of attaching to metal deck floors.
Concrete slabs where piping revisions are required and approved after slabs are poured.	Piping 3" and smaller may be supported at intermediate points by “Phillips”, or other approved 3/4" expansion bolts and shields, provided main supports are welded to structural steel and such main supports are welded to structural steel and such main supports are not less than 20 feet on centers. Intermediate supports for piping 4" and larger shall be attached to concrete beams or columns by means of 4" x 4" x 3/8" thick clip knee angles with 3/4" expansion bolts in shear (horizontal) and supporting rod at 90 from anchor bolt.

2.6 THERMOSTATIC RADIATOR CONTROL VALVE

A. Provide a thermostatic radiator control valve at each perimeter heating water horizontal branch pipe and as indicated on the drawings and details.

B. The Thermostatic Radiator Control Valve shall be selected to perform accurate temperature control by preventing overheating.

C. The size, type and configuration must be applicable to the system operating conditions, including pressures.

D. The operator (control) must be of the bellows type with either a liquid or vapor fill. The valve must be nickel-plated and must contain an EPDM disc and O ring gland seal.

E. The seal must be replaceable without special tools while the system is in operation.

F. The operators shall be with built-in sensors.

2.7 FLOW MEASURING FOR WATER SYSTEMS

A. Furnish and install flow measuring system.

B. Venturi System:

1. Furnish and install one complete Venturi Metering System as manufactured by Barco-Rinco Division of Aeroquip Corporation, Barrington, Illinois, Preso Industries Corporation. This shall be a coordinated system, including individual Venturi Flow Stations and Portable Master Meter, supplied by one manufacturer. Each Venturi station shall be complete with safety shut off valves, fill line size bypass with shut-off valve metal identification tag on chain, giving pipe size, Venturi series station identification, and meter reading at specified flow rate. Entire station shall have same pressure ratings as specified for valves. Venturi size and series shall be selected so that the design flow rate shall be between 10 and 40 inches of water pressure differential on a 0 - 50 meter or 12" - 80" on a 0 - 100" meter, with permanent pressure loss of not more than 10% of indicated flow rate differential pressure. Upstream pipe diameters shall be five (5), and downstream pipe diameters shall be two (2) as recommended by manufacturer.

2. Master Meter shall consist of dry type meter supplied with scale reading from zero (0) to 50 inches or zero (0) to l00 inches of water differential pressure, and shall be mounted in a portable carrying case, complete with two (2) 10 ft. lengths of checking hoses, blow down valves, installation and operating instructions, and capacity curves.

C. Turbine Meter:

1. The meter shall be an insertion turbine flow meter. The turbine meter shall have a linearity of ±1.0% and repeatability of 0.25% with a rangeability of 10:1. (There shall be an indicating meter on the local control panel that will indicate rate of flow and total flow and provide an input signal to the microprocessor controllers.)

2. Provide flow measuring stations for each of the following systems:

(a) _____

(b) _____

2.8 STEAM SPECIALTIES

A. Provide steam traps, Armstrong, Spirax-Sarco or approved equal, for venting and draining of steam condensate. Locate at ends of mains, bottom of risers, outlet of steam equipment, and all other points where condensate and air may collect, every 200 feet or less Traps shall pass condensate and air automatically without passing steam. Test in factory to insure operation. Provide strainer at inlet to each trap.

B. Size trap capacities for 200% of steam loads at a maximum drop of ½ psi. Trap capacity should be rated in general accordance with ANCI PTC 39.1 or FCI 87-1. Traps shall be sized with condensate at steam temperature.

C. Thermostatic traps shall be of the corrugated bellows balanced pressure type, bellows of red brass or phosphor bronze.

D. Traps up to and including 2-1/2" shall have flanged or threaded connections. Traps 1" and less shall have union connections.

E. Each steam heating unit, regardless of type, shall be installed with shut-off valve at inlet. Each radiator or convector shall have at its supply inlet, a bronze body valve of packless quick-opening type which shall pass sufficient steam when fully opened to fully heat the radiator surface with the lowest pressure carried in the mains.

F. For each system with 100% outside air provide a thermal drain on each float and thermostatic trap set to open when condensate in trap drops below 75°F. Drain shall be Spirax-Sarco "Thermoton" or approved.

G. Low Pressure Thermostatic Traps (0 PSI - 15 PSI)

1. Low pressure (0-15 psi) Thermostatic traps are to have cast or forged brass bodies suitable for 125 psi pressure and shall be provided with a union connection at the inlet. Self-aligning valve heads and seats for the low pressure traps shall be of suitable, non-corrosive material. Seats shall be removable, similar to Spirax-Sarco Type T or approved equal.

H. Low Pressure Combination Float & Thermostatic Traps (0 PSI - 15 PSI)

1. Combination Float and Thermostatic Traps shall have a valve mechanism, the position of which is controlled by a closed, stainless steel ball float. The seat of the valve will be watertight at all times. The action of this type of trap must discharge the condensate as soon as it enters the trap and its rate of discharge must be proportionate to the rate of the flow of condensate to the trap.

2. The traps shall be provided with an automatic, thermostatic air by-pass of the balanced pressure, multiple bellows types, or diaphragm capsule.

3. All working parts shall be of non-corrosive metal, (hard bronze, monel or stainless steel) and shall be removable without disconnecting the piping. Floats to be of stainless steel. Valve heads and seats are to be of stainless steel.

4. Body and cover to be of high grade cast iron suitable for 125 psi pressure for a 0-15 psi line, similar to Spirax-Sarco FT-15, or Armstrong Series "B."

I. Inverted Bucket Traps for Medium & High Pressure Steam 16 PSI to 250 PSI:

1. Provide inverted bucket steam traps with stainless steel internals and ability to have bent hole in bucket be self cleaning. Trap to shut tight on no load and work well over long period of time.

2. Trap must shut tight on no load and must discharge charge air and/or condensate as soon as condensate reaches the trap.

3. Thermo-Dynamic traps or other equivalent type shall not be used on equipment employing modulating control valves.

J. Thermodynamic Disc Traps:

1. Thermodynamic disc type, stainless steel body, disc and cap with only one moving part. Integral seat design with three equally spaced balanced outlet ports, non-gasketed sealing caps and Rockwell 50C hardened disc and integral seat working surfaces. Trap to operate close to saturated steam temperature without steam loss at all pressures from 3.5 psig to 1740 psig and against back pressures up to 80% of inlet pressure. Spriax-Sarco Model TD/TDS.

K. <u>Schedule of Steam Trap Types</u>

Drips for 0 to 30 psig mains and risers:	FT
Drips for mains and risers over 30 psig:	TD
Radiators, convectors, fin-tube radiators:	T
Air heating, blast coils, preheaters and reheaters:	FT
Hot water heaters:	FT
Tank heaters:	FT
Unit heaters:	FT
Flash tank discharge:	F
Heat exchangers:	FT
Absorption refrigeration machine:	FTB

Code:

FT	-	Float and Thermostatic Trap
TD	-	Thermo-Dynamic Trap
T	-	Thermostatic Trap
FTB	-	Float and Thermostatic Trap (high capacity)
IB	-	Inverted Bucket
F	-	Float Trap

2.9 STEAM HUMIDIFIERS

A. Humidifier shall receive steam at supply pressure and discharge at atmospheric pressure.

B. Separating chamber shall be of a volume and design that will disengage and remove all water droplets and all particulate matter larger than 3 microns when humidifier is operating at maximum capacity. A stainless steel filtering medium shall be included, to remove particulate matter in the chamber.

C. The metering valve shall be steam heated and shall have a plug, capable of modulating flow of steam to provide full control over the entire stroke of the operator. Hysteresis of the valve shall be less than 1/2 psig over 100% of valve travel.

D. The internal drying chamber shall receive steam at essentially atmospheric pressure and be jacketed by steam at supply pressure. Asbestos shall not be used anywhere in the humidifier.

E. The silencing chamber shall be steam jacketed and utilize a stainless steel silencing medium.

F. The distribution manifold or manifolds shall provide uniform distribution over its entire length and be jacketed by steam at supply pressure to assure that vapor discharged is free of water droplets. A full length stainless steel internal silencing screen shall be provided if required for sound control.

G. Humidifier shall be equipped with an interlocked temperature switch to prevent the humidifier from operating before start-up condensate is drained.

H. Humidistats specified under "Automatic Controls" will control electric control valve.

I. Provide steam piping, two gate valves, strainer, check valve, and inverted bucket steam trap for each humidifier.

J. Spill condensate from humidifier to drain pans in unit where applicable.

K. Where more than two manifolds are required, the piping shall be as follows. The manifolds shall be jacketed and trapped separately from the humidifier. The

humidifier shall receive steam directly from the steam supply line. The trap for the manifolds shall be an F & T trap. The trap for the humidifier shall be an inverted bucket type.

L. Number of manifold and control valves as required by humidifier manufacturer for various duct or air handling unit heights.

2.10 ELECTRIC EVAPORATIVE HUMIDIFIER

A. Humidifier shall be a VAPORSTREAM, Humidifier UL Listed, electric hot element evaporative humidifier as manufactured by DRI-STEEM Humidifier Company, Eden Prairie, MN, or approved equal. having the following features and devices.

B. Stainless Steel Construction: Vaporizing chamber, gasketed cover and fittings shall be constructed of 304 stainless steel with heli-arc welded seams. Chamber shall be capable of operating under a pressure of at least 18" W.C. without steam or water leaks.

C. Standard/DI Water: The humidifier shallrun on standard water, however, it shall have the capability of being field converted to run on demineralized water without being removed from the installation. This shall be accomplished through the use of a universal prove/float assembly and a software change.

D. Quick Removal Cover: The cover shall be secured by quick removal threaded knobs. The gasket shall be held in place by flanges that are formed as part of the cover and as part of the evaporating chamber. Theses flanges shall interlock in such a way that the sealing gasket is locked between them.

E. Immersion Heater(s): Heater(s) shall be Incoloy alloy sheathed resistance type heater(s) designed for no more than 95 watts per square inch. They shall be fastened through the top of the evaporating chamber thus providing for convenient removal for inspection.. The two threaded ends of each heater element shall pass through the top of the evaporating chamber and be secured with threaded nuts to buss bars. Design of heater shall provide for expansion and contraction, thus flaking off scale as it accumulates.

F. Thermal Overload Protection: A manual reset temperature switch shall be factory mounted and wired above a heating element offset to a level above the other heating elements in the evaporating chamber ensuring heater protection in the event of liquid level failure.

G. Heating Element Terminal Cover: A factory mounted and wired door interlock safety switch shall de-energize the heaters when the cover is removed. This provides easy access to quick change heating elements.

H. Inspection Plate/Sediment Tray: Provide tray to catch and hold minerals to facilitate periodic clean-out. This tray rests on the floor of the evaporating chamber. The scale that is shed by the heaters is caught in the tray and the tray is easily removed through the inspection opening for emptying.

I. Electronic Water Level Control for Hard or Softened Water: System shall provide for automatic refill, low water cut off and adjustable skimmer bleed-off functions. System shall consist of:

1. A water level sensing unit comprised of three metallic probes screwed into a threaded probe head. Probe head shall incorporate probe isolation skirts to eliminate short circuiting between probes caused by mineral coating of probe head. Probe head shall be mounted on the top of the vaporizing chamber.

2. A solenoid operated fill valve, brass body type, factory mounted on the front of the humidifier. A cleanable strainer with fine mesh screen shall be mounted upstream of valve. Fill opening shall be 1-1/2" above overflow.

3. Microprocessor Control System.

J. Surface Skimmer/Overflow: Shall be provided which is electronically adjustable to provide for optimum mineral removal with minimum water waste.

K. Control Cabinet: Shall be UL/CSA Listed JIC enclosure. Control devices shall be mounted on a removable sub-panel within the enclosure. Control devices shall include Microprocessor Control System, SCR Controller for each heater, control circuit transformer, fuse set for each heating stage, numbered terminal strip and such other optional devices as hereinafter specified and all interconnecting wiring. A wiring diagram is to be included and attached inside of cabinet door.

L. Microprocessor Control System: Shall be factory mounted and wired in the humidifier control panel with humidity sensors to be shipped loose for field installation by this contractor. Provide necessary contacts for remote monitoring/control by BMS. Mounting instructions and a wiring diagram shall be included and provide the following features and functions:

1. LED “heartbeat” fault indicator. Performs software self-diagnosis at every start-up.

2. Water make-up valve control and low water safety shutdown.

3. Auto drain-flush sequence whereby microprocessor accumulates actual humidifying “ON” time, and activates auto drain/flush sequence.

4. End of season drain function which activates when there has been no demand for humidification over a 72 hour period.

5. Four position functional slide switch on microprocessor board with stops at, “AUTO”, “STANDBY”, “DRAIN”, AND “TEST”.

Electrical contactors shall be cycled equally for long life.

Microprocessor Control System Keypad/Digital Display Module: Shall be housed in a thermoplastic enclosure (4-1/2"w x 6"h x 1-1/2"d). Module shall be shipped loose for field mounting (wiring by this contractor) and shall provide the following features:

M. The alphanumeric digital display portion shall continuously scroll all system functions including:

1. Actual space R.H. (via remote sensor located within the tenant space served by the system, furnished by this contractor)

2. Humidistat set point R.H. (Humidistat furnished by this contractor

3. Discharge duct R.H. (Humidistat furnished by this contractor)

4. High limit humidistat set point R.H. (Humidistat furnished by this contractor)

5. Per heater demand % (or humidifier % multiple humidifier system). Total system demand (in % of total humidifier capacity) total system output (lbs/hr or kg/hr).

6. “Time until service” message

7. High limit Stat and air flow proving circuit condition.

8. Aquastat for freeze protection. (Aquastat furnished by this contractor

N. The keypad portion shall enable the user to reset or adjust the following functions:

1. Humidistat R.H. setpoint

2. Humidistat R.H. high limit setpoint

3. Auto drain/flush frequency interval

4. Auto drain duration

5. Auto flush duration

6. PID loop

7. Throttling range adjustment

8. Time to go until next auto drain/flush sequence

9. Setting of cycle and delay times for proportional control device

10. Electronic skim timer

11. Humidity and temperature transmitter trim adjustments

Factory Mounted Control Cabinet: Cabinet shall be factory attached to side of humidifier and all wiring between cabinet and humidifier shall be completed at factory.

Dual Keypad/Digital Display Modules: Provide two keypad/digital display units, one for local display in the immediate vicinity of the humidifier and the other at a remote location. In addition provide for interface with the BMS (all wiring by this contractor).

O. Master/Slave Control Option:

1. System shall consist of a Master and Slave control management system to control multiple humidifier units (up to 4 humidifiers, 16 heater groups). Heater groups shall be energized or de-energized sequentially while one group modulates, thus providing vernire control. System shall automatically

rotate modulating duty between all heater group to equalize operational time and sequence drain/ flush cycles to allow only one humidifier to drain at a time.

P. Control Accessory:

1. Air Flow Proving Switch:

   Vane Type: A vane operated “sail switch” shall be provided for field installation.

2. Duct High Limit Humidistat: A high limit humidistat having a range of 15% to 95% shall be shipped loose for field installation. Humidistat shall sense humidity level within the duct and protect against saturation of air stream.

3. VAV Control Package: Two modulating electronic humidity sensors (one space mounted, the other duct mounted downstream of the humidifier) shall be shipped loose for field installation. Each shall transmit its sensing to the Microprocessor Control System which, in turn, shall modulate the humidifier output thereby maintaining the highest duct humidity possible at all air flow volumes, without saturation of the air stream.

Q. SCR Controllers: Provide SCR controllers for all humidifiers. Provide in control panel, a 100% solid state, power controller. Matching low voltage humidistats shall be shipped loose for field installation (by this contractor). Entire system shall modulate from zero to 100% of rated load.

R. Factory Insulation: Humidifier shall be covered with 1" thick, rigid, foam duct insulation. Insulation shall be covered with reinforced aluminum foil. All surfaces under the removable heater access panel shall be covered.

S. Support Legs: Four support legs, of length to provide 24" between underside of humidifier and floor, shall be provided

T. Dispersion Tube System: Furnish and install a Dispersion Tube System in each of the air handling units. Each tube bank shall consist of a header/separator and required quantity of dispersion tubes necessary to achieve the required steam capacity and absorption distance. Header/separator shall span the width of the duct, be constructed of stainless steel and be fitted with nipples for dispersion tube connections. Steam dispersion U-tubes shall be 1-1/2" OD, .049" wall, type 304 stainless steel. The dispersion tubes shall extend the width of the duct/air handling unit and shall be fitted with two rows of tubelets centered on the diametric line and spaced 1-1/2" apart. These tubelets shall be made of non-metallic material designed for steam temperatures. Each tubelet shall extend through the wall of and into the center of the dispersion tube and incorporate a properly sized calibrated orifice. For securing the Upper ends of the tubes a 1x1½” channel shall be furnished which the installer shall attach to the duct or housing.

U. Heater Thermostat: A manual reset overheat temperature thermostat mounted in humidifier for redundant protection to main controller.

V. NEMA 12 Rated Fan Ventilation: To provide fan ventilation for humidifier controls installed in the control cabinet. Control enclosure is provided with electric operated

exhaust fan, inlet filter grill and step down transformer all mounted and wired (by this contractor).

W. Cold Snap Offset Option: Provide and install on an appropriate window surface a temperature sensor. Sensor shall transmit its signal to the VAPOR-LOGIC which shall lower the indoor RH to a level 5% below the dew point RH thus preventing window condensation. The indoor RH shall be automatically returned to the normal setting when the glass temperature rises.

X. Provide a tempering device similar to Drane Kooler. The device shall temper the hot water or condense steam being drained from the humidifier. The device shall include a mixing chamber and fittings constructed of 304 stainless steel with welded seams. It shall include a self contained brass body tempering valve which shall be temperature adjustable and charged bulb type. The unit shall also include a 3/4" brass bold type drain valve and vacuum breaker. Connect to cold water supply.

2.11 CONVERTORS & EXCHANGERS

A. Furnish and install on suitable pipe frame on structural steel supports, converters and exchangers of size and capacity as scheduled on the drawings. Manufacturer shall be as noted on drawings or approved equal.

B. Convertors:

1. Steam to water convertors shall be water tube hot water heaters of the U-type with steam in the shell and water in the tube. Heater shell shall be constructed of carbon steel plate of ample thickness for the specified pressure with one bumped head, and flange at the other end of the shell. Tube sheet shall be of heavy steel or cast iron, accurately drilled for all tubes. All heating surfaces shall be composed of 3/4" diameter #18 B.W.G. seamless drawn copper U-tubes securely expanded into the tube sheet at one end and properly supported at the other end. All parts of the heater shall be designed for a working pressure of at least 125 p.s.i. in the steam spaces and suitable for the system working pressure in all water spaces. Heater shall have all necessary outlets, drain and vent connections.

2. Furnish and install for each convertor the following appurtenances:

(a) Steam trap of ample capacity in the return connection (of Webster, or approved, heavy duty trap) with approved Relief valve or valves (Watts Regulator or approved) for connection with the water outlet pipe (between the heater and the shut-off valve). Relief valves shall be furnished by exchanger manufacturer and shall comply with ASME Code. Valves shall be sized to relieve the full output of the convertor in BTU per hour. A vacuum breaker valve shall be mounted on the shell of the heat exchanger.

3. Water to Water Exchangers (Chilled Water to Chilled Water) shall conform to the following: Primary water through tubes, secondary water in baffled shell. Channel type construction with removable cover plate for inspection of tubes with breaking pipe connections. Straight tube construction with fixed tube sheet at each end of shell. Removable return head at far end. Shell and channel shall be fabricated steel ASTM A-285 Gr. C. Tubes shall

be Seamless Copper 3/4" OD x l8 Ga. Shell flanges and cover plate shall be steel ASTM A-201 Gr.B. Baffles to be steel. Provide relief valve or valves on secondary water side between exchanger and shut-off valves set l5 p.s.i. above the normal working water pressures at the exchanger. Relief valves shall be furnished by exchanger manufacturer in conformance with applicable codes.

C. This Contractor shall furnish and install all auxiliary steel required for support of all convertors and exchangers.

D. All heat exchangers shall be selected for .0005 fouling factor.

E. Convertors shall be A.S.M.E. constructed and furnished with insurance certificates.

2.12 EXPANSION & COMPRESSION TANKS

A. One or more tanks as required shall be provided for each water system and shall be of the sizes noted on the drawings. Expansion tanks shall be constructed of steel, welded, in accordance with the ASME Code for Unfired Pressure Vessels for a working pressure of 125 psig or 150 percent of maximum operating pressure, whichever is greater. Tanks shall be installed horizontally or vertically as shown on drawings.

B. Each expansion tank shall be piped and fitted in accordance with standard details.

C. Tanks shall be provided with cast iron or steel saddles and structural steel supports from floor except that tanks may be supported from the ceiling structure when load points are detailed on structural drawings. Horizontal tanks of not over 250-gallon capacity may be supported from the ceiling by means of solid steel straps, secured as required for pipe hangers. 80-gallon capacity or smaller tanks may also be supported on cast iron or steel brackets properly secured to walls or columns.

D. Compression tanks shall have one or more ASME rated pressure relief valves set 10% above system working pressure.

2.13 CONDENSATE RECEIVING TANKS & FLASH TANKS

A. One or more tanks as required shall be provided of the sizes noted on the drawings. Talks shall be constructed of steel, welded, in accordance with the ASME Code for Unfired Pressure Vessels for a working pressure of 125 psig or 150 percent of maximum operating pressure, whichever is greater. Tanks shall be installed horizontally or vertically as shown on drawings.

B. Each tank shall be piped and fitted in accordance with standard details.

C. Tanks shall be provided with cast iron or steel saddles and structural steel supports from floor except that tanks may be supported from the ceiling structure when load points are detailed on structural drawings. Horizontal tanks of not over 250-gallon capacity may be supported from the ceiling by means of solid steel straps, secured as required for pipe hangers. 80-gallon capacity or smaller tanks may also be supported on cast iron or steel brackets properly secured to walls or columns.

D. Each tank not vented to the atmosphere shall have one or more ASME rated pressure relief valves set 10% above system working pressure.

E. Internal piping if required by details shall be stainless steel.

2.14 PROPELLER TYPE UNIT HEATERS & ENTRANCE HEATING UNITS (HOT WATER)

A. Furnish and install all unit heaters as shown on the drawings.

B. Unit heaters shall be of the propeller type, suspended as indicated and arranged for horizontal discharge of air. Unit heaters shall be of sizes and capacities as scheduled on the drawings. Heaters shall be of manufacture as noted on drawings or approved.

C. Heating elements shall be copper tube coil with aluminum fins mechanically bonded to copper tubes, shall be properly pitched for drainage, and shall be designed for a working pressure of 200 psi or greater as per system pressures required for valves and fittings.

D. The casing shall be solidly and rigidly built, and finished with lacquer or enamel.

E. Propeller type fans shall be driven by motors of adequate horsepower. Motors shall be provided with thermal overload protection.

F. Furnish and connect to the return of each steam unit heater a float and thermostatic trap of ample capacity, a hand valve, and unions for trap removal.

G. The heaters shall be controlled automatically by means of thermostats located where shown on the drawings which shall start and stop the fans as described under "Automatic Temperature Controls".

H. Furnish and install entrance heating units as shown on the drawings with controls as described under "Automatic Controls".

2.15 PROPELLER TYPE UNIT HEATERS & ENTRANCE HEATING UNITS (ELECTRIC)

A. Furnish and install all unit heaters as shown on the drawings.

B. Unit heaters shall be of the propeller type, suspended as indicated and arranged for horizontal discharge of air. Unit heaters shall be of sizes and capacities as scheduled on the drawings. Heaters shall be of manufacture as noted on drawings or approved.

C. The casing shall be solidly and rigidly built, and finished with lacquer or enamel.

D. Propeller type fans shall be driven by motors of adequate horsepower. Motors shall be provided with thermal overload protection.

E. The heaters shall be controlled automatically by means of local thermostats which shall start and stop the fans as described under "Automatic Temperature Controls."

F. Entrance heating units to be of a capacity as specified in the schedule. Provide fan section and casing construction as outlined in other sections of the specification. Provide 30% medium efficiency filters.

G. Lobby heating units shall be provided with electric heating coil sections with capacities as scheduled on the plans.

1. Electric heaters and controls shall be constructed in accordance with U.L. and NEC requirements.

2. Electric heater frame shall be constructed of heavy duty galvanized steel. All wire terminals and nuts shall be stainless steel. Element wires shall be of A-grade resistance (80% nickel, 20% chromium) and shall be derated to a limit of 35 watts per square inch.

H. Each heater shall be supplied with a built-in automatic reset thermal cut for primary safety protection, replaceable cutouts for secondary safety protection, airflow switch, fan interlock relay, magnetic type contractors (one per step), fuses per NEC, transformer and step controller.

1. Manufacturer to provide a discharge sensor to control leaving air temperature. Provide 3 steps of control as a minimum.

2. All controls shall be housed in a unit mounted control panel with hinged doors, capable of interlock with remote space thermostat.

3. All wiring, control and power, shall be factory installed to terminals such that field wiring is limited to power connections and extension of control terminals to the room thermostat and sail switch.

2.16 CABINET CONVECTORS

A. The convector elements shall consist of seamless copper tubes, non-ferrous fins and mild steel headers. No soldered or welded joints or compression couplings permitted. The convectors shall be designed for a working pressure as per system requirements for valves and fittings.

B. Convector elements shall be supported by the enclosure with approved brackets.

C. Convector shall be suited to the space conditions and shall be of manufacturer as indicated on the drawings or approved.

D. Furnish and install convector enclosures for all convectors. Enclosure shall be constructed as follows: Top, back, sides and bottom of cabinets shall be not less than No. 18 USS gauge steel, fronts shall be not less than No. 14 USS gauge steel, enclosure shall have inlet and outlet grilles.

E. All fully recessed and semi-recessed convectors shall be provided with 16 gauge frame or Perma-lap (top, bottom and sides). All convectors shall be prime coat finish.

F. All enclosures shall be braced to provide stiffness. Convectors shall be securely bolted to the wall. Provide 1/2 inch of rigid insulation on sides, top, bottom and back of all convectors installed in outside walls.

G. All convectors without thermostatic control shall be provided with a knob operated gear type damper.

H. Where indicated on drawings heating elements shall be installed in enclosures provided under another division of the work. This trade shall furnish and install the sheet metal lining and insulation, inlet grilles and outlet registers.

2.17 CABINET UNIT HEATERS

A. Furnish and install of manufacturer as shown on the plans, or approved, cabinet heaters of size and type indicated. Design system pressures as per valves and fittings.

B. Unit Casings - Casings shall be constructed of die-formed, heavy gauge steel parts, phosphatized for rust resistance, front and all exposed surfaces shall be brushed aluminum finish. All hardware used in the casing shall be plated for rust resistance. Cabinets shall be constructed with well-rounded corners, and shall be equipped with a removable front for access to the interior.

C. Heating Elements

Heating elements shall be constructed of copper tubes and aluminum plate-type fins. Tubes are to be 1/2" O.D., and shall be joined to the supply and return header by silver brazing. Headers are to be fabricated from heavy gauge steel with provision for receiving an air vent. The aluminum fins shall be spaced by means of an integral collar to insure proper spacing. The joint between fin and tube shall be obtained by mechanically expanding the tube within the collar to affect a permanently tight thermal contact. The heating elements shall be of the multi-pass serpentine type, with the supply and return connections both located at the same end of the unit.

1. Heating elements shall be held rigidly in the unit casing, yet provisions shall be made to allow freedom for expansion and contraction within the casing.

D. Fans - Fans shall be forward-curved, double-inlet aluminum, mounted on a large-diameter steel shaft. The shaft shall be carried by two permanently lubricated, rubber-mounted ball bearings at shaft ends. Fans, shaft, bearings and fan housings shall be mounted as an integral assembly on a heavy steel fan board which is bolted to the unit. Fan drive shall be the V-belt type employing a fixed-pitch fan shaft sheave and an adjustable pitch motor sheave. Motor sheave adjustment shall permit a 30% adjustment of fan speed. All motors shall be provided with built-in thermal overload protection of the automatic reset type, with on-off-automatic control switch.

E. Filters - All cabinet unit heaters shall be provided with dry type filters. Furnish 2 spare filters for each unit.

2.18 FINNED PIPE RADIATION AND ENCLOSURES (SILLINE)

A. Furnish and install where shown on the plans, silline radiation complete with one piece back panel, one-piece front enclosures, heating element, hangers and accessories . Silline radiation shall be of manufacturer as indicated on the drawings or approved. Design system pressures as per valves and fittings.

B. Enclosure front shall consist of a one-piece No. l6 gage steel cabinet, with curved, streamline louvre discharge grille and die-formed bottom air-inlet openings. Each enclosure front shall be rigidly braced by integral vertical channel braces. Each front

shall extend to the wall and be fastened to the back panel at both top and bottom. Each front enclosure shall have two spring-loaded thumb screw fasteners, spot-welded in position for quick installation or shall be snap-on type. Back panel shall be of one-piece, 20 gage steel. Back panel shall be prepunched for fastening to wall and attaching heating element hangers.

C. Support brackets for the heating elements shall attach to the back panel. They shall be vertically adjustable for pitch, and shall provide for free longitudinal movement for expansion and contraction. Hanger bars shall be installed with nylon trim to prevent noise during expansion and contraction of heating element.

D. No sheet metal screws or other fastenings devices shall be visible when enclosure is installed below eye level. Where two or more enclosure sections are joined end to end, rolled enclosure edges shall form a neat butt joint without butt straps or other concealing devices. No unfinished metal edges of the ensemble shall be visible.

E. Heating elements shall be constructed of corrugated 015" aluminum fins mechanically expanded to seamless type "M" copper tubing. One end of each heating element shall be provided with swaged ends to permit end-to-end jointing.

F. Enclosures and accessories shall be finished in a hard baked (in a color selected by the architect) enamel finish. Enclosure and accessories shall be cleaned and phosphate coated before finishing.

G. All accessories shall be die-formed of l8-gage steel, and shall be shaped to match the enclosure form. All corners shall be rounded and all surfaces smooth. Accessories shall have no exposed metal edges, and fastening devices shall not be visible in below-eye-level installation. All necessary accessories shall be provided to permit wall-to-wall installation without cutting enclosures.

H. <u>End Caps</u> - Where one or more sill line enclosures are shown on the plans in a short-of-wall installation, the ensemble shall be finished at either end with a smooth rounded end cap. End cap shall provide a bottom or back knockout for piping as required.

I. <u>Corners</u> - Where two enclosures meet at a 90° inside or outside corner, rounded corner pieces shall be used.

J. <u>Sleeves</u> - Where sill-line ensemble runs wall-to-wall or corner-to-corner, fitted sleeves shall be used in conjunction with wall strips or corner pieces. Sleeves shall have rounded edges, and shall be shaped to telescope over enclosure, concealing variations between the overall enclosure length and the actual room length. Sleeves shall be arranged on combination with properly selected enclosure lengths to permit unbroken wall-to-wall installation without cutting enclosures.

K. Wall Strip - Where sill-line installations run wall-towall, wall strips shall be used to finish out the ensemble to the end walls. Wall strips shall provide a neat, tight groundjoint between the sleeve and the end wall.

L. <u>Full Access Valve Compartment</u> - For access to valves, balancing fittings, etc., a one foot piece of sill-line enclosure shall be provided. This one foot piece of enclosure shall match the sill-line ensemble and be complete with two spring loaded, thumb screw fasteners, spot welded in position for easy removal of and replacement of the enclosure.

M. Column Enclosures - Where indicated on the plans, piping around columns shall be concealed in column enclosures provided by the radiation manufacturer. These enclosures shall consist of one-piece back panels, rounded front panels, and trim strips. Hangers for supporting piping shall be included. Column enclosures shall be suitable for cutting and fitting at the job site to conform to column dimensions, and shall be finished to match the enclosure.

N. Dampers - Each enclosure without thermostatic control shall be provided with a knob-operated screw mechanism and shall be modulating control of the convective heating capacity.

2.19 BURIED HOT WATER PIPING

A. All underground and aboveground hot water lines with fluid temperatures up to 250° shall be the POLY-THERM type, as manufactured by PERMA-PIPE.

B. All straight sections, fitting, anchors and other accessories shall be factory fabricated to job dimensions and designed to minimize the number of field welds.

C. Each system layout shall be computer analyzed by the piping system manufacturer to determine stress on the carrier, pipe, and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ANSI B31.1, latest edition. Factory trained field technical assistance shall be provided for critical periods of installation; unloading, field joint instruction, and testing.

D. Internal piping shall be standard weight carbon steel. All joints shall be butt-welded for 2 ½" and greater, and socket or butt-welded for 2" and below. Where possible, straight sections shall be supplied in 18' or longer random lengths with 8" of piping exposed at each end for field joint fabrication.

E. All system components shall be designed and factory fabricated to prevent the ingress of moisture into the system.

F. Carrier pipe insulation shall be spray applied nominal 2 pound per cubic foot density, polyurethane foam for straight sections and performed polyurethane foam for all fittings. To ensure no voids are present, all insulation shall be inspected by one of the following three methods: visually checked prior to application of the protective jacket; infrared inspection of the entire length; or x-ray inspection of the entire length. The insulation thickness shall not be less than as specified under another section.

G. All straight sections of the insulated piping system shall be fully jacketed in a filament wound, polyester resin/fiberglass reinforcement composite directly applied on the insulating foam. Thermoplastic casing material, e.g., PVC or PE, shall not be allowed.

H. The minimum thickness for FRP jacket shall be as follows: For jacket diameter up to 15.5 inches-thickness = 0.055 inches; jacket diameter between 15.6 and 24.5 inches-thickness = .085 inches; jacket diameter between 24.6 and 31.0 inches-thickness = .110 inches; and jacket diameter between 31.1 and 40.0 inches-thickness = .140 inches.

I. All fittings of the insulated piping system shall be prefabricated to minimize field joints and jacketed in a chopped spray-up, polyester resin/fiberglass reinforcement composite, directly applied onto the insulating foam to a thickness related to the filament wound jacket thickness.

J. Field Joints:

1. The internal pipe shall be hydrostatically tested to 150 PSIG or 1½ times the operating pressure, whichever is greater. Insulation shall then be poured in place into the field weld area. All field applied insulation shall be placed only in straight sections. Field insulation of fittings shall not be acceptable. The mold for the polyurethane shall be made of clear adhesive backed polyester film. The installer shall seal the field joint area with wrappings of glass reinforcement fully saturated with a catylzed resin identical in properties to the factory-applied resin. Backfilling shall not begin until after the jacket has cured. All insulation and coating materials for making the field joint shall be furnished by PERMA-PIPE.

K. Backfill:

1. A 6" layer of sand or fine gravel shall be placed and tamped in the trench to provide a uniform bedding for the pipe. The entire trench width shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 12 inches above the top of the insulated piping system. The remaining trench shall be evenly and continuously backfilled in uniform layers with suitable excavated soil.

2.20 SNOW MELTING SYSTEM

A. The system shall consist of pumps, convertors, piping, controls, anti-freeze, etc.

B. Provide for each grid section factory lubricated teflon coated plug valve on supply and return lines.

C. Piping shall be securely supported at maximum 6'-0" O.C. with proper alignment and pitch for draining. The system shall be tested for leaks with air or nitrogen at 25 psig minimum.

D. The heating medium shall be 42.7% ethylene glycol.

E. Wherever possible single length of piping shall be used for all grids. Welding will be permitted only if single length piping is not available. Couplings will not be permitted. Grid piping shall be welded into headers in a manner to insure freedom from weld drips maintaining clean full area bores.

F. Entire piping system shall be electrically checked for freedom from stray current. (No electrical grounding to the system will be permitted).

G. Provide cathodic protection in the form of two magnesium anodes with test leads to a convenient terminus.

2.21 UNDERGROUND STEEL CONDUIT

A. Conduit:

1. All conduit straight lengths shall be welded smoothwall of not less than 10 gauge wall thickness black steel for all sizes and shall be tested at the factory to insure air and watertight welds prior to any fabrication or application of resin coatings. Conduit surfaces, inside and outside, shall be cleaned and made free of all loose scale and mill coatings by sand blasting to clean bright metal, and care shall be taken to maintain the surfaces free of oil and grease, before application of coatings. After sandblasting, the conduit surfaces, inside and outside, shall be given a prime coat of epoxy resin modified for the purpose intended and in preparation for the finish coats. Finish coat of epoxy resin on interior surface shall be applied in one pass to effect a final minimum coating thickness of not less than 6 mils. Exterior finish coat shall be applied to a minimum thickness of 20 mils by the additional application of two alternately applied layers of glass cloth and in such a manner as to fully impregnate each layer with resin as the layers are applied.

2. All primer coats and finish coats shall be of the catalytic epoxy type, unmodified except for necessary dispersants and flow control agents, total modification not to exceed five percent of the vehicle solids. No modification or substitution of additional coatings of other types is permissible. The iron-oxide-zinc chromate catalyzed primer shall contain not less than 60 per cent solids after mixing the two components but before reduction. Of these solids the iron oxide pigment shall be 1.50 - 2.00 pounds per gallon and shall contain not less than 75 percent ferric oxide. The zinc chromate shall be .50 pounds per gallon minimum and the magnesium silicate 1.5 to 2.0 pounds per gallon. The vehicle portion of the primer shall consist of 65 percent epoxy resins (Shell 1001) and 35 per cent resinous curing agent with no more than 5 per cent of the vehicle as stabilizer and flow control agents.

3. The finish coat shall contain not less than 60 percent solids after mixing the two components but before reduction. The pigment shall consist of 2 pounds per gallon of chromium oxide with the addition of not more than 3

percent of the pigment as dispersants and suspending agents. The finish coat vehicle shall consist of (Shell 1001) epoxy resin and a resinous Nitrogen containing curing agent in the ratio of 65 per cent epoxy resin to 35 per cent curing agent with the addition of not more than 5 per cent of stabilizers and flow control agents.

4. Final outside coating shall be subjected to a spark test and be capable of maintaining dielectric strength of 10,000 volts.

5. Conduit closures of suitable length complete with pipe insulation shall be furnished by the system manufacturer and shall be cylindrical in form of l0 gauge steel with a single horizontal side split. Closures shall be supplied with necessary prime coating and one finish coat, inside and outside, of epoxy resin same as conduit.

6. Installation of closures shall occur in the field by the Contractor at points of field joints between straight units or fabricated fittings, and shall be welded centrally over conduit ends between such adjacent units.

7. After welding a pressure testing using 15 lbs. air shall be made, and all welds shall be examined and checked for leaks by applying a soapy solution to the weld area. Any leaks shall be rewelded and the system retested until airtight at 15 lbs. pressure.

8. The Contractor shall furnish all necessary equipment and labor to perform the air test, including air compressor, gauges, conduit caps, temporary pipe and connections, etc., and complete the test to the satisfaction of the architect and/or engineer.

9. Upon completion of test and as soon thereafter as possible, all field welds on closures shall be cleaned of all welding slag, burned coating, mud, etc., by wire brushing.

10. Coupler shall then be finish coated in accordance with the system manufacturer's instructions, using materials supplied.

11. Finished coating shall then be spark tested as hereinbefore specified for straight units.

12. Additional conduit accessories as hereinafter specified shall have all exposed surfaces coated with resin same as conduit.

13. The whole system, prior to backfill, shall be subjected to a final spark test, and any electrical leaks caused by scuffing or other physical damage to coating shall be made good.

B. Pipe and Pipe Supports

1. All piping in conduit shall be as specified for the service required. All field pipe joints shall be welded by competent mechanics and hammer tested under hydrostatic pressure of 250 psi or twice the working pressure, whichever is greater, unless otherwise specified. Concealed pipe welds in fabricated conduit fittings shall be factory tested the same as specified for field welds, prior to assembly.

2. Piping shall be suitably spaced in the conduit and shall be supported in such a manner to avoid stress on wear on the pipe and/or insulation. Pipe supports shall consist of full, round insulating discs with specially corrugated steel band outer periphery to allow free air passage within the casing from one side to the other and to afford minimum line contact with inner surface of conduit. Supports shall be spaced on not more than 10'-0" centers with metal surfaces of supports protected with epoxy resin coating same as for conduit.

C. Expansion Loops, Ells and Tees

1. Prefabricated ells, loops and tees shall be furnished and installed where shown on plans and shall consist of pipe, insulation, and conduit conforming to the same specification as hereinbefore specified for straight runs. Expansion loops shall be of proper design in accordance with stress limits indicated by A.S.M.E. Code for pressure piping, District Heating Section. Loop piping shall be installed in conduit suitably sized to handle indicated pipe movement.

D. End and Gland Seals

1. Terminal ends of conduits inside manholes, pits or building walls shall be equipped with end seals consisting of a steel bulk head plate welded to the pipe and conduit. Where there is no anchor within five feet of a terminal end, conduits shall be equipped with gland seals consisting of a packed stuffing box and gland follower mounted on a steel plate welded to end of conduit. End seals or gland seals shall be equipped with drain and vent openings located diametrically opposite on the vertical center line of the mounting plate and shall be shipped to the job site with plugs in place.

E. Waterstops or Leakplates

1. All conduits shall terminate 1" beyond inside face of manhole or building walls to prevent condensation drip from spilling over exposed piping insulation in pits. Conduit shall be equipped with leak plates or water stops located in wall approximately 5" from terminal ends to provide effective moisture barrier.

F. Anchors

1. Prefabricated plate anchors shall be furnished and installed where shown on plans and shall consist of a steel plate, welded to pipe and conduit. The steel plate shall be 3/8" thick for 6" to 10" conduit, 1/2" thick for 11-1/8" to 20" conduit and 3/4" thick for conduit over 20".

2. A concrete block shall be cast over the plate and conduit and shall be large enough for firm anchorage into undisturbed trench sidewalls. The concrete block to be at least 30" in length and extend a minimum of 9" beyond the top and bottom of anchor plate.

G. Pipe Insulation

1. All pipe or pipes in conduit, as hereinafter specified, shall be insulated with machine-molded 1-1/2" fiberglass cloth jacket. Side joints of insulation jackets shall be double stitch sewn with fiberglass thread and with end joints telescoped not less than 2 inches when applied. For chilled water piping, refer to insulation section.

2. The factory prefabricated insulated pipe conduit specified above shall be Imperial Line as supplied by Ric-Wil Incorporated, Barberton, Ohio, or equal, and installed under the supervision of a factory installation supervisor.

H. Cathodic Protection

1. Cathodic protection shall be provided for the buried systems furnished under these specifications.

2. The cathodic protection system consists of furnishing the design and materials, and performing all operations necessary to provide a flow of direct current from sacrificial anodes to the underground heating and cooling distribution systems.

3. The manufacturer of the heating conduit system shall be responsible for furnishing the design and materials for the cathodic protection of their particular system.

4. The system shall be designed with not less than 7% of the heating conduit surface considered bare and not less than 2 milliamps of current per square foot of bare surface. Seventeen pound magnesium anodes shall be used, sufficient for a 30 year life.

5. Test stations shall be provided along the conduit, not more than 500 feet apart, to test performance after installation. Terminate test leads at ground surface in a cast-iron housing encased in concrete, with approximately 18" of slack lead. Where buildings or structures are close by, test leads shall be housed in electrical conduit and terminated in waterproof junction boxes affixed to the structure.

6. Arrangements shall be made to electrically isolate the heating and cooling distribution piping under cathodic protection from other buried structures.

7. Special attention shall be given to buried electrical connections. These connections must be carefully checked and protected before backfilling. Backfill material around buried wires shall be free of stone and other sharp objects.

8. Before commencement of the installation, an earth resistivity survey shall be undertaken along the line of conduit, employing specialists in that field. At this time, samples of soil at anticipated pipe depth shall be obtained and the chemical analysis and electrical resistivity for each sample determined. Chemical analysts shall include pH, percentage of water soluble salts, chloride content and sulphate content A minimum number of five samples shall be taken from representative locations along the route.

9. Before final acceptance of the cathodic protection system, a detailed, dimensional drawing shall be furnished showing exact locations of all anodes, test stations and the routes of all connecting cables. Methods of installing the materials shall also be detailed on this drawing.

10. The system shall be tested after installation has been completed and a report submitted. Additional anodes or alterations shall be provided as required for satisfactory operation of the system.

11. Proper installation of the cathodic protection system in accordance with the drawings shall be the responsibility of the contractor. However, a technically qualified representative from the designers of the cathodic protection system shall be present during the installation of the anodes and the test stations. The representative shall report in writing to the consulting engineers any work not in conformance with his recommendations. On completion of the work, the company responsible for the design of the cathodic protection system shall submit a certified letter stating that the installation has been made in accordance with the specifications and their recommendations.

12. The system under this section of the specifications shall be guaranteed for a period of one year from date of acceptance thereof. Upon receipt of notice of failure of any part of the system, during the guaranty period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the contractor.

2.22 THERMOMETERS AND PRESSURE GAUGES

A. Furnish and install pipe thermometers with separable sockets in the following locations. This applies to all systems described in the specification. Thermometers to be rated at minimum range 150% and maximum 200% of working temperature.

1. In and out of each cooling tower.

2. In and out of each refrigerant condenser and chiller. Thermometers as required under "Refrigeration Equipment".

3. In and out of each converter and water to water exchangers (on water side).

4. In return secondary water and in mixed water line after bleed valves on all bleed systems.

5. In and out of each chilled water coil. A vertical bank of coil sections may have one thermometer on inlet header and one on outlet header. For these systems with two vertical banks of coils, then each bank shall have a thermometer on inlet and outlet headers.

6. In and out of each heating coil in main air supply rig. A vertical coil bank section may have one thermometer on inlet header and one on outlet header. For those systems with two vertical banks of coils, then each bank shall have a thermometer on inlet and outlet headers.

7. In condensate receiving or dilution tanks.

B. Furnish and install pressure gauges in the following locations on water lines:

1. At inlet and outlet of each circulating pump and upstream of inlet strainer. One gauge may be used in lieu of two on suction side of pump with suitable valves and piping. Pressure gauges to be rated at minimum 150% and maximum 200% of working pressure. If suction head on pump is below 5 PSI, furnish a compound gauge. Pumps to be provided with gauges in tapping provided for by pump vendor in pump nozzles.

2. At inlet and outlet of refrigerant water chiller.

3. At inlet and outlet of refrigerant condenser.

4. At inlet and outlet of each converter and water to water exchanger (on water side).

5. At inlet and outlet of each coil bank. For those systems with two banks of three coils each, each bank shall have separate gauges. Locate gauges immediately downstream of shut-off valve on supply line, and immediately upstream of shut-off valve on return line.

6. On discharge of condensate pumps.

7. As required for compressed air lines described under automatic controls.

C. See "Automatic Controls" for description of air thermometers to be provided by automatic control manufacturer.

D. Thermometers for water systems shall be direct red reading, 9" vertical scale, 1 degree increments, manufactured by Weksler, Moeller, or Taylor and shall be minimum 4-1/2 inch dial type, aluminum flangeless case.

1. Pipe insertion dial thermometers shall have separable sockets of a material suitable for each given installation. Sockets for insulated lines shall have 2-1/2" extension necks.

2. They shall be of the adjustable angle type to permit easy adjustment of the thermometer case, to facilitate reading after installation.

E. Pressure gauges shall have 4-1/2" diameter dials, cast aluminum case, wide phosphor bronze bourdon, stainless steel movement, micrometer adjustment pointer, 1/2 of 1% accuracy, ranges as required. Shut-off cock shall be provided

between each gauge and piping to permit removing gauge while system is under pressure. All gauges on steam piping shall be provided with syphons. All gauges on pumps shall be provided with pressure snubbers. Gauges as specified above shall be TRERICE 500X series, WEKSLER AAI series, WEISS PG series, ASCHROFT Duragauge series, or approved equal. Mount gauges so that they are clearly visible from floor level. Provide extension tubing as required.

2.23 PLATE HEAT EXCHANGER

A. The plate heat exchangers shall be shipped to the site as completely assembled units. The exchangers shall be pressure tested and flushed clean at the factory prior to shipment. All nozzle connections shall be factory sealed prior to shipment to prevent the entrance of foreign matter into the heat exchangers during shipment, storage and installation.

B. Applicable Codes and Standards:

1. The plate heat exchangers shall be factory tested in accordance with the requirements of Section VIII, Div. I of the ASME Code.

2. Flanged nozzle connections shall conform to ANSI B16.5 standards, and shall be of the pressure rating design as indicated on the schedule. Pressure ratings assume full pressure on one side and zero pressure on the other side. Studded port construction is not acceptable.

C. Design Requirements:

1. Heat exchanger performance and design shall be in accordance with the schedule. Surface area shown per plate heat exchanger is the minimum acceptable. All performance calculations must include a minimum of ten percent (10%) additional surface for fouling. Calculated heat transfer surface area, with and without the additional fouling surface, must be indicated on the manufacturer's submitted performance calculation data sheets. Heat transfer rates fouled in excess of 750 BTU/HR/FT^2/Deg. F are not acceptable.

2. Pressure drops in pounds per square inch across each circuit of the plate heat exchanger indicated on the schedules are the maximum allowed.

3. Heat exchanger design is to be of diagonal flow to optimize fluid flow distribution across the plate surfaces.

D. Construction Requirements:

1. Plates shall be fabricated from SA312-304 stainless steel having a 2B finish. Pattern shall be Chevron and shall be of a minimum thickness as indicated for the following Design/Test Pressure requirements:

(a) 150 psi design/225 psi test - .024 inches minimum plate thickness.

2. Gaskets shall be of a one piece molded design formulated of Nitrile rubber. Inactive port gasket areas shall be vented to the exterior in such a manner that no mixing can occur between fluid circuits.

3. Nozzles shall be flanged and shall comply with the requirements of ANSI B 16.5 for a 300 pound - 150 pound rating where applicable.

4. Heat exchanger frames shall have a minimum of two external lifting lugs per frame.

5. Each heat exchanger shall be fitted with a removable galvanized steel plate pack shroud with attached lifting handles; and shall completely enclose the plate pack, front/rear covers, and tie bars.

6. Plates shall be supported from an upper carrying bar and positioned by a lower guide bar. Plates shall not require the use of additional hanging clips for either support or positioning.

7. Frame shall be constructed of carbon steel in sufficient thickness and strength to operate within the designated design and test pressures. Design strength calculations are to be submitted at the Engineer's request.

8. Frame tightening bolts shall receive a rust-protective coating of molybdenum grease and shall also be covered with plastic sleeves.

9. All exposed frame parts shall be surface prepared to an SSP-6 finish, receive two prime coats of a glycerophtalic zinc chromate primer and two finish coats of an epoxy enamel to a minimum dry film thickness of 3mm.

E. Testing and Certification:

1. All factory hydrostatic testing of the plate heat exchangers is to be scheduled in conjunction with the Engineer to determine if the Engineer deems it necessary to have his representative available.

2. The plate heat exchanger manufacturer is required to make factory representation available should field thermal and/or pressure testing be required.

F. Approved Manufacturers:

1. Plate heat exchangers are as manufactured by American Vicarb Corporation.

2. Other manufacturers' plate heat exchanger equipment will be considered for approval providing:

(a) All design, construction and performance specifications are strictly adhered to; and

(b) Sufficient reference material can be supplied by the manufacturer exhibiting a minimum of five years similar industry experience.

PART 3 - EXECUTION

3.1 PREPARATION

A. Clean piping before welding.

3.2 INSTALLATION

A. Installation of Appurtenances and Sensors in Piping:

1. Provide all fittings, wells and openings required for installation of devices to indicate flow, temperature, pressure, etc., in piping systems.

B. Piping Systems - General:

1. The drawings indicate schematically the size and location of piping. Piping shall be set up and down and offset to meet field conditions and coordination between trades without additional cost. Piping shall conform to the latest revisions of ANSI/ASME B31.9 - "Building Services Piping."

2. Pipework shall conform fully to the following requirements:

(a) Provide proper provision for expansion and contraction in all portions of pipework, to prevent undue strains on piping or apparatus connected therewith. Provide double swings at riser transfers and other offsets wherever possible, to take up expansion. Arrange riser branches to take up motion of riser.

(b) Approved bolted, gasketed, flanges (screwed or welded) shall be installed at all apparatus and appurtenances, and wherever else required to permit easy connection and disconnection. Screwed unions with steel faces can be used on piping 1" or less.

(c) All piping connections to coils and equipment shall be made with offsets provided with screwed or welded bolted flanges so arranged that the equipment can be serviced or removed without dismantling the piping.

(d) If, after plant is in operation, any coils or other apparatus are stratified or air bound (by vacuum or pressure), they shall be repiped with new approved and necessary fittings, air vents, or vacuum breakers at no extra cost. If connections are concealed in furring, floors, or ceilings, this trade shall bear all expenses of tearing up and refinishing construction and finish, leaving same in as good condition as before it was disturbed.

3. Pitch steam and condensate lines downward in direction of flow to ensure adequate flow and prevent noise and water hammer. At low points of steam lines provide traps adequately sized to collect condensate. Mains shall be dripped at least every 100 feet of run. All supply mains shall be dripped and trapped on any vertical lift. Provide capped dirt pockets at all traps, riser heels, and wherever dirt and scale may accumulate. To meet job conditions, mains shall set up (with drip connections to return line) to maintain headroom, clear other pipes, etc. Steam mains are to be installed as high as possible. System is to be arranged to secure venting of air to the return line at all low points in steam mains, without permitting ingress of air. In any case, where return or drip piping, to meet job conditions, may have to set down under stoops, doors, etc., and again rise after passing these, the sets shall be made up with 45 degree fittings and with Y-laterals at each end, with brass plugs to permit easy cleaning of trapped portions of pipe. At any points where return mains have to rise again, after being depressed, provide also approved overhead "air lines" (not smaller than 3/4" in size) with adjusting valves, and connect with two high sides. Any turns in water sealed lines shall be made with crosses, with brass plugs in unused outlets to facilitate cleaning. All apparatus subject to high temperature differentials and high steam demand loads such as outdoor air heating coils, domestic hot water heaters and steam-water converters, shall have a vacuum breaker installed as shown on details.

4. Pitch water piping upward in direction of flow to ensure adequate flow without air binding, and to prevent noise and water hammer. Branch connections to mains are to be made in such a manner to prevent air trapping and permit free passage of air. To meet job conditions mains shall set up to maintain headroom, and clear other trades. Provide oversized float operated automatic air vent (with valve & strainer) at all high points particularly at the highest points of return mains and risers and high points of supply risers. Avoid 90 degree lift set-ups in supply lines by using 45 degree ells. Where 90 degree lifts exceed 12" install automatic air vent in supply lines. All lifts in return lines shall be installed with automatic air vents. Pipe outlet of all automatic air vents to an open sight drain if the vent is concealed, or to within two feet of the floor within machine rooms.

5. Miscellaneous drains, vents and reliefs are to be provided as follows:

   (a) Provide 1" drain valves with caps at the heel of all interior main water risers. Provide 1/2" drain valves with caps at the heel of all perimeter water risers.

   (b) Miscellaneous drains, vents, reliefs, and overflows from tanks, equipment, piping relief valves, pumps, etc., shall be run to the nearest open sight drain or roof drain. Provide drain valves whenever required for complete drainage of piping, including the system side of all pumps.

   (c) Provide domestic water connections from valved outlets to any equipment requiring same.

(d) Provide automatic relief valves set 50# psi below rating pressure of all hot water heating vessels on vessel or in leaving hot water line on vessel side of any valve.

(e) Contractor shall cap or plug in all systems, all open ended valves for future connections, drains and vents. Also, in order to prevent a dead leg of water and consequent corrosion, provide a 1" open bypass from supply to return with balancing valve in all open condenser water systems.

6. Screwed piping shall conform to the following:

(a) Pipe nipples - Any piece of pipe 3" in length and less shall be considered a nipple. All nipples with unthreaded portion 1-1/2" and less shall be extra heavy. Only shoulder nipples shall be used. No close nipples will be provided.

(b) Screw threads shall be cut clean and true; screw joints made tight without caulking. No caulking will be permitted. A non-hardening lubricant will be permitted. No bushings shall be used. Reductions, otherwise causing objectionable water or air pockets, to be made with eccentric reducers or eccentric fittings. All pipe shall be reamed out after cutting to remove all burrs.

END OF SECTION 15500

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SECTION 15530 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes refrigerant piping used for air conditioning applications. This Section includes:

1. Pipes, tubing, fittings, and specialties.

2. Special duty valves.

3. Refrigerants.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section 15010 - Basic Mechanical Requirements.

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is a part of each Division 15000 Section.

E. Division 7, Section "Roof Accessories" for roof curbs, piping supports, and roof penetration boots.

1.3 SUBMITTALS

A. Product data for the following products:
1. Each type valve specified.
2. Each type refrigerant piping specialty specified.

B. Shop Drawings showing layout of refrigerant piping, specialties, and fittings including, but not necessarily limited to, pipe and tube sizes, valve arrangements and locations, slopes of horizontal runs, wall and floor penetrations, and equipment connection details. Show interface and spatial relationship between piping and proximate to equipment.

C. Brazer's Certificates signed by Contractor certifying that brazers comply with requirements specified under "Quality Assurance" below.

D. Maintenance data for refrigerant valves and piping specialties, for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 15 Section "Basic Mechanical Requirements."

1.4 QUALITY ASSURANCE

A. Qualify brazing processes and brazing operators in accordance with ASME "Boiler and Pressure Vessel Code," Section IX, "Welding and Brazing Qualifications".

B. Regulatory Requirements: Comply with provisions of the following codes:

1. ANSI B31.5: ASME Code for Pressure Piping - Refrigerant Piping.

2. ANSI/ASHRAE Standard 15: Safety Code for Mechanical Refrigeration.

1.5 SEQUENCING AND SCHEDULING

1. Coordinate the installation of roof piping supports, and roof penetrations. Roof specialties are specified in Division 7.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Refrigerant Valves and Specialties:

(a) Alco Controls Div, Emerson Electric.

(b) Danfoss Electronics, Inc.

(c) EATON Corporation, Control Div.

(d) Henry Valve Company.

(e) Parker-Hannifin Corporation, Refrigeration and Air Conditioning Division.

(f) Sporlan Valve Company.

2.2 PIPE AND TUBING MATERIALS

A. General: Refer to Part 3, Article "PIPE APPLICATION" for identification of systems where the below specified pipe and fitting materials are used.

B. Copper Tubing: 1/4" & 3/8" OD: ASTM B, Type K, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing.

C. Copper Tubing: 5/8" OD & up: ASTM B 88, Type L, hard-drawn straight lengths, and soft-annealed coils, seamless copper tubing.

D. Tubing shall be factory cleaned, ready for installation, and have ends capped to protect cleanliness of pipe interiors prior to shipping.

2.3 FITTINGS

A. Wrought-Copper Fittings: ANSI B16.22, streamlined pattern.

2.4 JOINING MATERIALS

A. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (Silver).

2.5 VALVES

A. General: Complete valve assembly shall be UL-listed and designed to conform to ARI 760.

B. Globe: 450 psig minimum operating pressure, 275 deg. F minimum operating temperature; cast bronze body, with cast bronze or forged brass wing cap and bolted bonnet; replaceable resilient seat disc; plated steel stem. Valve shall be capable of being repacked under pressure. Valve shall be straight through or angle pattern, with solder-end connections.

C. Check Valves - Smaller Than 7/8 inch: 500 psig minimum operating pressure, 300 deg. F minimum operating temperature; cast brass body, with removable piston, Teflon seat, and stainless steel spring; straight through globe design. Valve shall be straight through pattern, with solder-end connections.

D. Check Valves - 7/8 inch and Larger: 450 psig minimum operating pressure, 300 deg. F minimum operating temperature; cast bronze body, with cast bronze or forged brass bolted bonnet; floating piston with mechanically retained Teflon seat disc. Valve shall be straight through or angle pattern, with solder-end connections.

E. Solenoid Valves: 250 deg. F temperature rating, 400 psig working pressure; forged brass, with Teflon valve seat, two-way straight through pattern, and solder end connections. Provide manual operator to open valve. Furnish complete with NEMA 1 solenoid enclosure with 1/2 inch conduit adapter.

F. Evaporator Pressure Regulating Valves: pilot-operated, forged brass or cast bronze; complete with pilot operator, stainless steel bottom spring, pressure gage tappings, and wrought copper fittings for solder end connections.

G. Thermal Expansion Valves: thermostatic adjustable, modulating type; size as required for specific evaporator requirements, and factory set for proper evaporator superheat requirements. Valves shall have copper fittings for solder end connections; complete with sensing bulb, a distributor having a side connection for hot gas bypass line, and an external equalizer line.

H. Hot Gas Bypass Valve: adjustable type, sized to provide capacity reduction beyond the last step of compressor unloading; and wrought copper fittings for solder end connections.

2.6 REFRIGERANT PIPING SPECIALTIES

A. General: Complete refrigerant piping specialty assembly shall be UL-listed and designed to conform to ARI 760.

B. Strainers: 500 psig minimum working pressure; forged brass body with monel 80-mesh screen, and screwed cleanout plug; Y-pattern, with solder end connections.

C. Moisture/liquid Indicators: 500 psig minimum operation pressure, 200 deg. F minimum operating temperature; forged brass body, with replaceable polished optical viewing window, and solder end connections.

D. Filter-driers: 500 psig minimum operation pressure; steel shell, flange ring, and spring, ductile iron cover plate with steel capscrews, and wrought copper fittings for solder end connections. Furnish complete with replaceable filter-drier core kit, including gaskets, as follows:

1. Standard capacity desiccant sieves to provide micronic filtration.

E. Suction Line Filter-Drier: 350 psig minimum operation pressure, 225 deg. F minimum operating temperature; steel shell, and wrought copper fittings for solder end connections. Permanent filter element shall be molded felt core surrounded by a desiccant for removal of acids and moisture for refrigerant vapor.

F. Flanged Unions: 400 psig minimum working pressure, 330 deg. F minimum operating temperature; two brass tailpiece adapters for solder end connections to copper tubing; flanges for 7/8 inch through 1-5/8 inch unions shall be forged steel, and for 2-1/8 inch through 3-1/8 inch shall be ductile iron; four plated steel bolts, with silicon bronze nuts and fiber gasket. Flanges and bolts shall have factory-applied rust-resistant coating.

G. Flexible Connectors: 500 psig minimum operating pressure; seamless tin bronze or stainless steel core, high tensile bronze braid covering, solder connections, and synthetic covering; dehydrated, pressure tested, minimum 7 inch in length.

H. Provide mufflers on all air cooled condensers

I. Provide relief valves and piping to atmosphere as required by local codes.

2.7 REFRIGERANT

A. Refrigerant No. 22, in accordance with ASHRAE Standard 34.

PART 3 EXECUTION

3.1 EXAMINATION

A. Examine rough-in for refrigerant piping systems to verify actual locations of piping connections prior to installation.

3.2 PIPE APPLICATIONS

A. Mechanical fittings (crimp or flair) are not permitted.

3.3 PIPING INSTALLATIONS

A. General: Install refrigerant piping in accordance with ASHRAE Standard 15 - "The Safety Code for Mechanical Refrigeration."

B. Install piping in as short and direct arrangement as possible to minimize pressure drop.

C. Install piping for minimum number of joints using as few elbows and other fittings as possible.

D. Arrange piping to allow normal inspection and servicing of compressor and other equipment. Install valves and specialties in accessible locations to allow for servicing and inspection.

E. Provide adequate clearance between pipe and adjacent walls and hanger, or between pipes for insulation installation. Use sleeves through floors, walls, or ceilings, sized to permit installation of full thickness insulation.

F. Insulate suction lines. Liquid line are not required to be insulated, except where they are installed adjacent and clamped to suction lines, where both liquid and suction lines shall be insulated as a unit.

1. Do not install insulation until system testing has been completed and all leaks have been eliminated.

G. Install branch tie-in lines to parallel compressors equal length, and pipe identically and symmetrically.

H. Install copper tubing in rigid conduit in locations where copper tubing will be exposed to mechanical injury or where passing through areas not served by this system.

I. Slope refrigerant piping as follows:

1. Install horizontal hot gas discharge piping with 1/2" per 10 feet downward slope away from the compressor.

2. Install horizontal suction lines with 1/2 inch per 10 feet downward slope to the compressor, with no long traps or dead ends which may cause oil to separate from the suction gas and return to the compressor in damaging slugs.

3. Install traps and double risers where indicated, and where required to entrain oil in vertical runs.

4. Liquid lines may be installed level.

J. Use fittings for all changes in direction and all branch connections.

K. Install exposed piping at right angles or parallel to building walls. Diagonal runs are not permitted, unless expressly indicated.

L. Install piping free of sags or bends and with ample space between piping to permit proper insulation applications.

M. Conceal all pipe installations in walls, pipe chases, utility spaces, above ceilings, below grade or floors, unless indicated to be exposed to view.

N. Install piping tight to slabs, beams, joists, columns, walls, and other permanent elements of the building. Provide space to permit insulation applications, with 1 inch clearance outside the insulation. Allow sufficient space above removable ceiling panels to allow for panel removal.

O. Locate groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

P. Exterior Wall Penetrations: Seal pipe penetrations through exterior walls using sleeves and mechanical sleeve seals. Pipe sleeves smaller than 6 inch shall be steel; pipe sleeves 6 inch and larger shall be sheet metal.

Q. Fire Barrier Penetrations: Where pipes pass through fire rated walls, partitions, ceilings, and floors, maintain the fire rated integrity. Refer to Division 7 for special sealers and materials.

R. Make reductions in pipe sizes using eccentric reducer fittings installed with the level side down.

S. Install strainers immediately ahead of each expansion valve, solenoid valve, hot gas bypass valve, compressor suction valve, and as required to protect refrigerant piping system components.

T. Install moisture/liquid indicators in liquid lines between filter/driers and thermostatic expansion valves and in liquid line to receiver.

1. Install moisture/liquid indicators in lines larger than 2-1/8 inch OD, using a bypass line.

U. Install unions to allow removal of solenoid valves, pressure regulating valves, expansion valves, and at connections to compressors and evaporators.

V. Install flexible connectors at the inlet and discharge connection of compressors.

3.4 HANGERS AND SUPPORTS

A. General: Hanger, supports, and anchors are specified in Division 15 Section "SUPPORTS AND ANCHORS." Conform to the table below for minimum spacing of supports:

B. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet in length.

2. Roller hangers and spring hangers for individual horizontal runs 20 feet or longer.

3. Pipe rollers complete supports for multiple horizontal runs, 20 feet or longer supported by a trapeze.

4. Spring hangers to support vertical runs.

C. Install hangers with the following minimum rod sizes and maximum spacing:

NOM. PIPE SIZE	MAX. SPAN-FT	MIN. ROD SIZE - INCHES
1	7	3/8
1-1/2	9	3/8
2	10	3/8

D. Support vertical runs at each floor.

3.5 PIPE JOINT CONSTRUCTION

A. Brazed Joints: Comply with the procedures contained in the AWS "Brazing Manual."

B. Fill the pipe and fittings during brazing, with an inert gas (ie., nitrogen or carbon dioxide) to prevent formation of scale.

C. Heat joints using oxy-acetylene torch. Heat to proper and uniform brazing temperature.

3.6 VALVE INSTALLATIONS

A. General: Install refrigerant valves where indicated, and in accordance with manufacturer's instructions.

B. Install globe valves on each side of strainers and driers, in liquid and suction lines at evaporators, and elsewhere as indicated.

C. Install a full sized, 3-valve bypass around each drier.

D. Install solenoid valves ahead of each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at the top.

1. Electrical wiring for solenoid valves is installed by this contractor to meet requirements specified in Division 16. Coordinate electrical requirements and connections.

E. Thermostatic expansion valves may be mounted in any position, as close as possible to the evaporator.

1. Where refrigerant distributors are used, mount the distributor directly on the expansion valve outlet.

2. Install the valve in such a location so that the diaphragm case is warmer than the bulb.

3. Secure the bulb to a clean, straight, horizontal section of the suction line using two bulb straps. Do not mount bulb in a trap or at the bottom of the line.

4. Where external equalizer lines are required make the connection where it will clearly reflect the pressure existing in the suction line at the bulb location.

F. Install pressure regulating and relieving valves as required by ASHRAE Standard 15.

3.7 EQUIPMENT CONNECTIONS

A. The Drawings indicate the general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow servicing and maintenance.

3.8 FIELD QUALITY CONTROL

A. Inspect, test, and perform corrective action of refrigerant piping in accordance with ASME Code B31.5, Chapter VI.

B. Repair leaking joints using new materials, and retest for leaks.

3.9 ADJUSTING AND CLEANING

A. Before installation of copper tubing, clean the tubing and fitting using following cleaning procedure:

1. Remove coarse particles of dirt and dust by drawing a clean, lintless cloth through the tubing by means of a wire or an electrician's tape.

2. Draw a clean, lintless cloth saturated with trichloroethylene through the tube or pipe. Continue this procedure until cloth is not discolored by dirt.

3. Draw a clean, lintless cloth, saturated with compressor oil, squeezed dry, through the tube or pipe to remove remaining lint. Inspect tube or pipe visually for remaining dirt and lint.

4. Finally, draw a clean, dry, lintless cloth through the tube or pipe.

B. Verify actual evaporator applications and operating conditions, and adjust thermostatic expansion valve to obtain proper evaporator superheat requirements.

C. Inspect refrigerant piping systems in accordance with requirements of Division-15 Basic Mechanical Materials and Methods section "Pipes and Pipe Fittings".

D. Adjust controls and safeties. Replace damaged or malfunctioning controls and equipment with new materials and products.

3.10 COMMISSIONING

A. Charge system using the following procedure:

1. Install core in filter dryer after leak test but before evacuation.

2. Evacuate refrigerant system with vacuum pump; until temperature of 35 deg F is indicated on vacuum dehydration indicator.

3. During evacuation, apply heat to pockets, elbows, and low spots in piping.

4. Maintain vacuum on system for minimum of 5 hours after closing valve between vacuum pump and system.

5. Break vacuum with refrigerant gas, allow pressure to build up to 2 psi.

6. Complete charging of system, using new filter dryer core in charging line. Provide full operating charge.

B. Train Owner's maintenance personnel on procedures and schedules related to start-up and shut-down, troubleshooting, servicing, and preventative maintenance of refrigerant piping valves and refrigerant piping specialties.

C. Review data in Operating and Maintenance Manuals. Refer to Division 1 section "Project Closeout."

D. Schedule training with Owner through the Architect, with at least 7 days advance notice.

END OF SECTION 15530

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SECTION 15540 - HVAC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following categories of HVAC pumps for hydronic systems:

1. Vertical in-line Pumps (150 PSIG Working Pressure).

2. Vertical in-line Pumps (350 PSIG Working Pressure).

3. Closed Coupled, End-Suction Pumps.

4. Frame Mounted, End-Suction Pumps.

5. Horizontal Axial Split-Case, Double Suction Pumps

6. Duplex Condensate Pump units.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Section 15010 BASIC MECHANICAL REQUIREMENTS

2. Section 15050 BASIC MECHANICAL MATERIALS AND METHODS

3. This section is a part of each Division 15 section.

4. Division 16 ELECTRICAL

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Pump Pressure Ratings: At least equal to system's maximum operating pressure at point where installed, but not less than specified. Factory test at 1.5 times working pressure.

B. Water Temperature: Pump to comply with specific application.

C. Mounting: As described under "Vibration Isolation".

D. Pumps shall be selected to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25% beyond design capacity. In addition, the design impeller diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impeller diameter at the design speed for that model.

E. Rising Curve: Pump characteristic curve shall rise continuously from maximum capacity to shut-off, with shut-off head minimum 10 percent greater than the design head, except for double suction pumps to shut-off head shall be 20 percent greater than design head.

F. Working Pressure: Construct pumps for the working pressure in pounds per square inch specified or indicated. Factory test at 1.5 times working pressure.

G. Factory Tests: The pumps shall be factory tested, thoroughly cleaned and painted with (1) coat of machinery enamel prior to shipment. The manufacturer shall include a set of installation instructions with the pumps at the time shipment.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data including certified performance curves and rated capacities, brake horsepower, KW input and full load efficiency complying with motor efficiency requirements. In addition, include weights (shipping, installed, and operating), furnished specialties, and accessories. Indicate pump's operating point on curves.

C. Shop drawings showing pump layout and connections. Include setting drawings with templates, directions for installation of foundation and anchor bolts, and other anchorages.

D. Wiring diagrams detailing wiring for power, signal, and control systems and differentiating between manufacturer-installed wiring and field-installed wiring.

E. Product certificates signed by manufacturers of pumps, certifying accuracies under specified operating conditions and compliance with specified requirements.

F. Maintenance data for pumps to include in the operation and maintenance manual specified in Division 1. Include startup instructions.

1.5 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with provisions of the following:

1. ASME B31.9 "Building Services Piping" for piping materials and installation.

2. Hydraulic Institute's "Standards for Centrifugal, Rotary & Reciprocating Pumps" for pump design, manufacture, testing, and installation.

3. UL 778 "Standard for Motor Operated Water Pumps" for construction requirements. Include UL listing and labeling.

4. NEMA MG 1 "Standard for Motors and Generators" for electric motors. Include NEMA listing and labeling.

5. NFPA 70 "National Electrical Code" for electrical components and installation.

B. Single-Source Responsibility: Obtain each category of pumps from a single- source and by a single manufacturer. Include responsibility and accountability to answer questions and resolve problems regarding compatibility, installation, performance, and acceptance of pumps.

C. Product Options: Drawings indicate sizes, profiles, connections, and dimensional requirements of pumps and are based on the specific types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered. Refer to Division 1 Section "Product Substitutions."

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store pumps in dry location.

B. Retain shipping flange protective covers and protective coatings during storage.

C. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

D. Extended Storage Longer than 5 Days: Dry internal parts with hot air or vacuum-producing device. Coat internal parts with light oil, kerosene, or antifreeze after drying.

E. Comply with pump manufacturer's rigging instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Vertical In-Line Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Amtrol, Inc.

(c) Armstrong Pumps, Inc.

(d) Burks Pumps, Inc.; Weinman Pump.

(e) Deming Pump Co.

(f) Dunham Bush, Inc.

(g) Goulds Pumps, Inc.

(h) ITT Fluid Technology Corp.; Bell & Gossett Div.

(i) Paco Pumps, Inc.

(j) Peerless Pump Co.
(k) Taco, Inc.

2. Close-Coupled, End-Suction Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Burks Pumps, Inc.; Weinman Pump.

(c) Deming Pump Co.

(d) Dunham Bush, Inc.

(e) Goulds Pumps, Inc.

(f) ITT Fluid Technology Corp.; Bell & Gossett Div.

(g) Paco Pumps, Inc.

(h) Peerless Pump Co.

(i) Taco, Inc.

(j) Weil Pump Co.

3. Frame Mounted, End-Suction Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Burks Pumps, Inc.; Weinman Pump.

(c) Deming Pump Co.

(d) Dunham Bush, Inc.

(e) Goulds Pumps, Inc.

(f) ITT Fluid Technology Corp.; Bell & Gossett Div.

(g) Paco Pumps, Inc.

(h) Peerless Pump Co.

(i) Taco, Inc.

(j) Weil Pump Co.

4. Horizontal Axial, Split-Case, Double-Suction Pumps:

(a) Allis-Chalmers Fluid Products Co.; Industrial Pump Div.

(b) Burks Pumps, Inc.; Weinman Pump.

(c) Deming Pump Co.

(d) Dunham Bush, Inc.

(e) Goulds Pumps, Inc.

(f) ITT Fluid Technology Corp.; Bell & Gossett Div.

(g) Paco Pumps, Inc.

(h) Peerless Pump Co.

(i) Taco, Inc.

(j) Weil Pump Co.

2.2 PUMPS, GENERAL

A. General: Factory assembled and tested.

B. Base-Mounted Pumps: Include pump casings that allow removal and replacement of impellers without disconnecting piping.

C. Types, Sizes, Capacities, and Characteristics: As indicated.

D. Motors: Furnish single-, multiple-, or variable-speed motors, with type of enclosures and electrical characteristics indicated and as specified under another section of this work. Include built-in thermal-overload protection and grease-lubricated ball bearings. Select each motor to be nonoverloading over full range of pump performance curve.

E. Factory Finish: Manufacturer's standard paint applied to factory-assembled and -tested units before shipping.

F. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

2.3 VERTICAL IN-LINE PUMPS (150 PSIG Working Pressure)

A. Description: Vertical, in-line, centrifugal, closed coupled, single-stage, radially split case design. Include vertical-mounting, bronze-fitted design and mechanical seals rated for 150 psig minimum working pressure and a continuous water temperature of 250 deg F. Include the following:

1. Casing: Cast iron, with suction and discharge flanges of the same size for piping connections and located on a common center line 180 degrees apart for mounting in the pipe line, drain plug in bottom of volute, and threaded gage tappings at inlet and outlet connections. Flanges shall be 125 pound ANSI drilling with a casing working pressure of 175 psi. Pumps shall include a volute type casing suction branch to minimize pumping noise.

2. Impeller: ASTM B 584, cast bronze, statically and dynamically balanced, enclosed, overhung, single suction, and keyed to shaft.

3. Wearing Rings: Replaceable, bronze casing ring.

4. Shaft and Sleeve: Ground and polished steel shaft with bronze sleeve and integral thrust bearing. Include flinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering motor bearings.

5. Seals: Mechanical type, suitable for 250 degrees F, with all metal parts to be 303 stainless steel Viton elastomers and ceramic seat, and carbon washer. A bypass shall ber provided between the seal faces and discharge flange to assure adequate venting of the seal chamber and to provide lubrication.

6. Motor: Direct mounted to pump casing. Include lifting and supporting lugs in top of motor enclosure.

2.4 CLOSE-COUPLED, END-SUCTION PUMPS

A. Description: Centrifugal, close-coupled, end suction pumps.

B. Type: Pumps shall be horizontal mount, single stage, vertical split case and designed for 150 psi (250F) working pressure.

C. Casings shall be cast iron designed for 150 PSIG (250F) working pressure or ductile iron for working pressures above 150 PSIG and rated at 350 PSIG (250F) working pressure, any part of which can be suction pressure. Discharge nozzle shall be capable of being swiveled through any of three positions for greater flexibility of application. A separate suction cover shall be bolted to the casing and aligned with a machined lock fit. Openings shall be provided for priming, venting, draining, and for suction and discharge gauge connections. Suction and discharge connections shall be flanged, ANSI suitable for working pressures scheduled on the drawings flat faced. Casings shall be provided with renewable bronze case wear rings to maintain proper running clearance and minimize leakage between suction and discharge side of casing.

D. Shaft and Sleeve: A replaceable bronze shaft sleeve shall be furnished to cover the wetted area of the shaft extending through the seal box.

E. Bearings: Provide regreasable ball bearings with 50,000 hour life, rated L10 and dust-sealed.

F. Seals: Hot water pump shall be provided with mechanical seals of carbon ring, Viton Elastomer and ceramic stationary seats. Condenser water and chilled water shall be provided with mechanical seals of carbon ring Buna elastomer and ceramic stationary seat. Provide a flushing line from the discharge volute to the flush seal cap. For condenser water pumps, provide an abrasive separate in the flushing line. For pumps rated at working pressures above 150PSIG, mechanical seals of stainless steel with a rotating face of babbitt filled carbon and a stationary face of tungsten carbide, balanced type designed for 250 degrees F.

G. Motor: Direct mounted to pump casing. Include supporting legs as integral part of motor enclosure. Motor shall be sized for non-overloading over full characteristic curve of the pump. Motors shall be close coupled type.

H. Impellers: Provide bronze impellers, statically and dynamically balanced, of the enclosed type, machined and polished. Impellers shall be securely fastened to the shaft by key and locked shaft collar. The vanes shall be designed to reduce noise.

2.5 FRAME MOUNTED, END-SUCTION PUMPS

A. Description: Horizontally mounted, base-mounted, centrifugal, separately coupled, end-suction, single-stage, bronze-fitted, vertically split case design with flexible couplings.

B. Casings: Cast iron designed for 150 PSIG (250F) working pressure or ductile iron for working pressures above 150 PSIG and 350PSIG (250F) working pressure, any part of which can be suction pressure. Discharge nozzle shall be capable of being swiveled through any of three positions for greater flexibility of application. A separate suction cover shall be bolted to the casing and aligned with a machined lock fit. Openings shall be provided for priming, venting, draining, and for suction and discharge gauge connections. Suction and discharge connections shall be flanged, ANSI suitable for working pressures scheduled on the drawings flat faced. Casings shall be provided with renewable bronze case wear rings to maintain proper running clearance and minimize leakage between suction and discharge side of casing.

C. Shaft and Sleeve: A replaceable bronze shaft sleeve shall be furnished to cover the wetted area of the shaft extending through the seal box. The shaft shall be high strength S.A.E. 1045 steel accurately machined and of sufficient size to transmit the maximum horsepower and loading from the impeller to the bearing impeller at the maximum allowable operating speed. Shaft shall be furnished with a deflector between the casing and bearing frame to prevent leakage of the fluid into the bearings.

D. Bearings: Provide greasable ball bearings with 50,000 hour life, rated L10 and dust-sealed.

E. Seals: Hot water pump shall be provided with mechanical seals shall be carbon ring, Viton Elastomer and ceramic stationary seats. Condenser water and chilled water shall be provided with mechanical seals of carbon ring Buna elastomer and ceramic stationary seat. Provide a flushing line from the discharge volute to the flush seal cap. For condenser water pumps, provide an abrasive separate in the flushing line. For pumps with working pressures above 150 PSIG, mechanical seals shall be stainless steel with a rotating face of babbitt filled carbon and a stationary face of tungsten carbide, balanced type designed for 250 degrees F.

F. Motor: Motor shall be sized for non-overloading over full characteristic curve of the pump.

G. Impellers: Provide bronze impellers, statically and dynamically balanced, of the enclosed type, machined and polished. Impellers shall be securely fastened to the shaft by key. A self locking cap nut and compression seal washer shall be used to clamp the impeller hub firmly against the shaft sleeve to prevent leakage between the impeller and shaft. The vanes shall be designed to reduce noise.

H. Flexible Couplings: For pumps with variable speed drives and constant speed over 40HP, provide Falk type “T” steel with coupling guard. For constant speed pumps with motors less than 40HP, Woods type will be permitted.

I. Coupling Guard: Steel, removable, and attached to mounting frame.

J. Mounting Frame: Welded-steel frame and cross members, factory-fabricated from ASTM A 36 (ASTM A 36M) channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Grind welds smooth before application of factory finish. Field-drill motor-mounting holes for field-installed motors.

K. Motor: Secured to mounting frame, with adjustable alignment.

2.6 HORIZONTAL AXIAL SPLIT-CASE PUMPS

A. Description: Base-mounted, centrifugal, separately coupled, single or double-suction, single-stage, bronze-fitted, horizontally axial split case design. Shut-off head shall be 20 percent greater than operating head.

B. Casings: Casing shall be horizontally split with upper and lower halves bolted together. Flanged suction and discharge connections shall be located in the lower to allow for removal of the upper half casing for inspection of the mechanical seal and allow for removal of the entire rotating element without distributing suction or discharge piping or pump and driver alignment. Construct of close-grained cast iron, or semi-steel designed for working pressure as schedule.

C. Bearing housing seats shall be cast integrally with the casing and seats for casing wear rings, stuffing box and bearing housing shall be bored in one machine to ensure alignment.

D. The upper casing shall have taps for stuffing box seal piping priming and vents. The lower casing shall have taps for gauges and draining in the bearing arms for removal of lubricating liquid.

E. Provide threaded openings for air removal, gland sealing and drainage. Provide brass air vent cocks, and 300 pound 3/4-inch brass drain valves.

F. Pumps shall be equipped with renewable bronze case rings designed so that hydraulic pressure will seat case rings against shoulder in pump case around the full periphery of the wearing ring. The wear rings shall be locked in place by doweling to prevent rotation. Pumps with 8 inches discharge and larger shall be furnished with Bronze impeller wear rings

G. Impellers: Bronze impellers, statically and dynamically balanced, of the enclosed type, machined and polished. Impellers shall be securely fastened to the shaft by key and locked shaft collar. The vanes shall be designed to reduce noise.

H. Shafts: The pump shaft shall be made of stainless steel, accurately machined to give true running rotating element.

I. Flexible Couplings: For pumps with variable speed drives and constant speed over 40HP, provide Falk type “T” steel with coupling guard. For constant speed pumps with motors less than 40HP, Woods type will be permitted.

J. Mechanical Seals: All pumps shall be provided with mechanical seals, sediment separators and flushing systems. Seals shall be John Crane type suitable for the pressure and service schedules on the drawings. Springs shall be of stainless steel and metal parts of seal head shall be of non-rusting material (brass or stainless steel). Carbon rotating washer shall be John Crane P1 or equal. Stationary seals shall be ceramic or equal. Balance seals shall be furnished where suction pressures exceed 150 PSI with stationary seats of tungsten carbide.

Pumps shall be fitted to allow for mechanical seal replacement without removing the casing upper half.

K. Shaft Sleeves: Provide removable shaft sleeves.

1. For seal pumps use 316 stainless steel sleeves, or 416 stainless steel shafts.

L. Glands: Glands shall be of the flush type design and constructed from ductile iron. Design of gland shall insure a flush of clean treated water to the seal face by means of a 1/4" soft copper flush line from the pump discharge to the flush connection in the gland. A “John Crane” abrasive separator shall be provided for each seal and piped into the flush line to insure clean treated water to the seal face. Seal chamber shall be integral with casing top and bottom and shall be interchangeable to accept packing or mechanical seals. Pumps rated at less than 200GPM do not require sediment separators.

M. Bearings: Provide heavy duty grease lubricated ball bearings rated for 80,000 hours, drain and fill plugs, and housed in line-bored bearing brackets cast integral with lower casing. Fit with doweled and bolted bearing caps.

N. Motor: Motor shall be sized for non-overloading over full characteristic curve of the pump.

O. Coupling Guard: Steel, removable, and attached to mounting frame.

P. Mounting Frame: Welded-steel frame and cross members, factory-fabricated from ASTM A 36 (ASTM A 36M) channels and angles. Fabricate for mounting pump casing, coupling guard, and motor. Grind welds smooth before application of factory finish. Field-drill motor-mounting holes for field-installed motors.

Q. Motor: Secured to mounting frame, with adjustable alignment.

2.7 PUMP SPECIALTY FITTINGS

A. Include the following pump specialty fittings with end connections matching pump and piping.

1. Suction Diffuser: Angle or straight pattern, cast-iron body and end cap, pump-inlet fitting. Include bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory- or field-fabricated support.

2.8 GENERAL-DUTY VALVES

A. Refer to other Division 15 Sections for general-duty gate, ball, butterfly, globe, and check valves.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment foundations, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting performance of pumps.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.

C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.

D. Do not proceed until unsatisfactory conditions have been corrected.

3.2 CONCRETE

A. Install concrete bases of dimensions required for pumps. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 15 Section "Basic Mechanical Materials and Methods."

3.3 INSTALLATION

A. Install pumps according to manufacturer's written installation and alignment instructions.

B. Install pumps in locations indicated and arranged to provide access for periodic maintenance, including removal of motors, impellers, couplings, and accessories.

C. Support pumps and piping separately so that piping is not supported by pumps.

D. Suspend in-line pumps using continuous-thread hanger rod and vibration-isolation hangers of sufficient size to support weight of pump independent of piping system.

E. Set base-mounted pumps on concrete foundation. Disconnect coupling halves before setting. Do not reconnect couplings until alignment operations have been completed.

1. Support pump base plate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches (19 to 38 mm) between pump base and foundation for grouting.

2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.

F. Bedplate (Motor Drive): Cast iron, channel steel or structural steel with drip collection chamber and tapped drain connections and a large opening for grouting. Jig drilled and tapped for pumps and NEMA frame motors. On close-coupled pumps, motor assembled as integral part of the complete unit; no bedplate required. Pumps and/or pumps sets shall be leveled with tapered steel wedges to allow a minimum of 3\4 inch pump base and inertia base or concrete pad.

G. Duplex Condensate Pump Units: Install units for collection of condensate. Make connection to drainage piping, as required.

3.4 ALIGNMENT

A. Align pump and motor shafts and piping connections after setting them on foundations, after grout has been set and foundation bolts have been tightened, and after piping connections have been made. Alignment shall be made with dial indicator to a tolerance of ±.002".

B. Comply with pump and coupling manufacturers' written instructions.

C. Adjust alignment of pump and motor shafts for angular and parallel alignment by 1 of 2 methods specified in the H.I.'s Standards for Centrifugal, Rotary & Reciprocating Pumps, "Instructions for Installation, Operation and Maintenance."

D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Fill base plate completely with nonshrink, nonmetallic grout, with metal blocks and shims or wedges in place. After grout has cured, fully tighten foundation bolts.

3.5 CONNECTIONS

A. Connect piping to pumps as indicated. Install valves that are the same size as piping connecting to pumps.

B. Install suction and discharge pipe sizes equal to or greater than the diameter of pump nozzles.

C. Install electrical connections for power, controls, and devices.

D. Electrical power and connections are specified in Division 16 Sections.

3.6 FIELD QUALITY CONTROL

A. Check suction piping connections for tightness to avoid drawing air into pumps.

B. Clean strainers.

C. Check Alignment.
D. Verify that piping is not supported by pump.

E. Set pump controls.

F. Guarantee: Pump to deliver required GPM against design and within ±3% without over-heating motor, bearings or any other parts and without producing noise audible outside the space in which the pumps are installed. Certified test statements to be provided for each pumping unit. Seals to be replaced without charge if faulty operation or unusual wear occurs during guarantee period, not caused by maintenance faults.

3.7 COMMISSIONING

A. Start -up: Pumps shall be installed in accordance with the standards of the Hydraulic institute.

B. Final Checks Before Startup: Perform the following preventive maintenance operations and checks before startup:

1. Lubricate bearings.

2. Remove grease-lubricated bearing covers, flush bearings with kerosene, and clean thoroughly. Fill with new lubricant according to manufacturer's recommendations.

3. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.

4. Check that pumps are free to rotate by hand. Pumps for handling hot liquids shall be free to rotate with pump hot and cold. Do not operate pump if it is bound or even drags slightly until cause of trouble is determined and corrected.

5. Check that pump controls are correct for required application.

6. The pump manufacturer shall check the motors and pumps for proper alignment glands for proper tightness and all bearings for proper lubrication before pumps are started.

7. The HVAC Contractor shall instruct the Testing and Balancing Subcontractor to take amperage readings on each phase of all pump motors and after 15 days Of operation the HVAC Contractor shall recheck and adjust as required alignment and gland tightness and bearing lubrication.

C. Starting procedure for pumps with shutoff power not exceeding safe motor power:

1. Prime pumps, opening suction valve, closing drains, and preparing pumps for operation.

2. Open cooling water supply valves in cooling water supply to bearings, where applicable.

3. Open sealing liquid supply valves if pumps are so fitted.

4. Open warm-up valves of pumps handling hot liquids if pumps are not normally kept at operating temperature.

5. Open circulating line valves if pumps should not be operated against dead shutoff.

6. Start motors.

7. Open discharge valves slowly.

8. Check general mechanical operation of pumps and motors.

9. Close circulating line valves once there is sufficient flow through pumps to prevent overheating.

D. When pumps are to be started against closed check valves with discharge shutoff valves open, steps are the same, except that discharge valves are opened sometime before motors are started.

E. Refer to Division 15 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

END OF SECTION 15540

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15545 - CHEMICAL WATER TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes chemical treatment systems for the following:

1. Hot-water closed heating systems.

2. Hot Water closed heating system with glycol.

3. Chilled Water closed System.

4. Steam Systems.

5. Boiler Water (H.P. Steam).

6. Boiler Water (L.P. Steam).

7. Deareator Systems.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to work of this Section.

B. This section is a part of each Division 15000 Section making reference to Water treatment and cleaning and the other sections of division 15000.

1.3 SCOPE OF WORK

A. Provide, for the full construction period as well as for 2 additional years starting from the date of acceptance by Owner, complete water treatment equipment, associated piping, chemicals and service for systems as specified and/or shown on the drawings. Equipment, chemicals and service shall be provided by the independent water treatment company. That company shall supervise the installation of the chemical feed equipment, chemical cleaning of the systems and testing. Provide all necessary wiring to an adequate source of electric power, and all required interwiring.

B. Dosage and Control

1. All chemical programs must be selected for the building's water supply, and must be adjusted so that when applied at the concentrations of active chemicals and cycles of concentration recommended by the Supplier, the programs will meet the performance requirements as specified herein.

C. It is responsibility of the Supplier to obtain and become familiar with all necessary building technical plant and operating information. Appointments must be made with facility management and engineering personnel for this purpose.

D. Daily records of all water treatment activities shall be maintained by the water treatment company and made available to the building operations personnel representing the owner. These records shall consist of all communications and test records from the water treatment company, all chemical additions, all fill and drain cycles, cleanings, additions to the piping system and any other pertinent data, starting at the first filling of the system.

E. The water treatment company shall include with service all required chemicals for testing, initial cleaning, startup treatments, test equipment and all chemicals required for the two year period during which service is rendered.

F. All service visits shall be confirmed in writing to the Owner so that complete record of service activities is available for examination by the Owner and engineer.

G. The water treatment company selected shall be responsible for insuring that all pipe systems and equipment for which they are responsible remain clean and free from all corrosion during all testing or filling and draining operations.

Under no circumstances shall raw, untreated water be introduced into these pipes and equipment or be allowed to remain in place anytime during construction. All hydronic testing shall only be with treated water at all times.

Upon completion of all building construction operations associated with the piping system in question, the system shall be cleaned by the water treatment company using appropriate chemicals which are nonaggressive to the materials in that pipe system, but which will clean surface rust, oil, grease and silt from the steel piping and other contaminants associated with the piping fabrication process.

Cooling systems shall be cleaned with an alkaline phosphate and/or detergent solution.

Chemicals for initial treatment of the water must be on-hand before cleaning is started, so that these chemicals can be added to the initial water fill after cleaning is complete. Under no circumstances shall the cleaned system be filled with untreated water or allowed to stand empty between cleaning and initial fill.

The start-up chemical treatment program shall be, at a minimum, 3-4 times the dosage of the maintenance chemical treatment program.

The cleaning operation shall be completed when agreed upon representative pipe lengths which have been in place during the entire building process have been satisfactorily cleaned as established by all interested parties.

H. At no time shall the Mechanical Contractor add water to a system without that water containing a corrosion inhibiting treatment chemical. The addition of minimal amounts of untreated water to an already treated system is allowed.

I. Hydrostatic Testing Corrosion Inhibitor

1. If sections of system must be hydrostatically tested prior to cleanout, appropriate inhibitor shall be added to the test water at sufficient level to totally passivate metal and provide protective film on pipe surfaces to prevent corrosion prior to cleanout and treatment. Mechanical Contractor shall be responsible to coordinate this treatment with the water treatment contractor.

2. At no time shall water be added to a system without that water containing a corrosion inhibiting treatment chemical.

J. All materials installed in the system such as pumps, pipe, fittings, dielectrics, relays, solenoid valves, flow switches, etc. shall have a pressure rating equal to or greater than the maximum calculated pressure expected at the installed locations.

1.4 MICROBIOLOGICAL CONTROL

A. The Supplier must provide a specific microbiological control program. Both oxidizing and non-oxidizing biocides are acceptable, along with biodispersants and other control measures. The program must list specific biocides with application dosages and frequency, and must include all of the information specified herein. Acquired immunity to one biocide must be considered.

1.5 CHEMICAL PROGRAMS

A. All chemicals provided for use in the open condenser water and all closed water systems, and for testing purposes, must meet all applicable EPA and OSHA requirement as well as all applicable federal, state and local regulations. In addition, all chemicals must meet the following criteria:

1. Toxicity

(a) Chemicals must be non-toxic to personnel and safe to handle when usual precautions are observed.

2. Disposal and Cleanup

(a) At use concentrations in the systems, all chemicals must be acceptable in the building's sewer system. The supplier must provide clear directions for cleanup of accidental chemicals spills, including necessary safety precautions, and must ensure that sufficient supplies and equipment required for cleanup of chemical spills are on hand for emergency use.

B. Furnish chemicals recommended by water treatment system company for treating water to meet specified water quality. Provide only chemicals that are compatible with piping materials, seals and all accessories.

1.6 PERFORMANCE

A. All chemical programs recommended for use in the building water and steam systems must meet or exceed the following performance guidelines.

1. Water Systems

		Open Systems	Closed Systems
(a)	Corrosion on mild steel	Less than 2.0 mpy	Less than 1.0 mpy
(b)	Pitting attack on mild steel	None	None
(c)	Corrosion on copper alloys	Less than 0.2 mpy	Less than 0.1 mpy
(d)	Scaling and deposition	None	None
(e)	Microbiological fouling	1. No visible deposits	No visible deposits
		2. No health hazards	No health Hazards
		3. Planktonic counts	Planktonic counts
		4. Less than 1 x 104/ml	Less than 1 x 103/ml

2. Steam Systems

		Condensate & Steam
(a)	Deposition	No detectable deposition
(b)	Corrosion	No detectable deposition
(c)	Oxygen Pitting	None
(d)	Dissolved oxygen	No detectable
(e)	Water and steam quality	As per ASME and other guidelines

B. Corrosion and Deposit Control

1. The supplier must provide a specific corrosion, scale and deposit control program for mild steel, copper alloys and any other metals present in the system. Corrosion inhibitors for each metal to be protected must be specifically identified.

1.7 CHEMICAL TREATMENT - WATER SYSTEM - DESCRIPTION

A. Chemical Treatment - Cleaning and Degreasing

The selected water treatment company shall provide a supervised program of cleaning and degreasing chemicals to be used in the specified system prior to startup. New Chillers, piping, and connected equipment shall be cleaned by circulating an alkaline product as specified by the equipment manufacturer or the water treatment company. Follow the cleaning procedure as specified in this section of the specification. All cleaning shall be in accordance with the National Association of Corrosion Engineers Recommended practice - NACE RP0182-95.

After cleaning is completed, the equipment shall be dumped, flushed with clean water and drained again and filled with water containing the correct corrosion inhibitors as supplied by the water treatment company. The initial chemical dose shall be twice the normal operating dose.

B. Chemical Treatment - Hot Water Closed Heating System

1. The water treatment company shall provide a suitable water treatment program for Closed Hot Water Systems. The program shall meet the performance requirements, as outlined above.

2. Provide a 5 gallon shot feeder including funnel, or 2" wide mouth valve opening and air relief valve for addition of chemicals to the system. Isolation valves and a low point drain shall be included in this piping system.

3. Chemical feed pumps, positive displacement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and discharge capacity to meet system requirements.

4. The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the controller and pump.

5. Coupon Rack

   (a) Furnish and install in addition to corrosion spool pieces, a coupon rack to monitor chemical treatment. Coupon rack to be fabricated from 1 inch diameter black iron pipe. Do not combine coupon rack with spool piece assembly. The coupon rack shall include, as a minimum:

      (1) Inlet and outlet shut-off valves and low point drain.
      (2) Wye strainer.
      (3) Corrosion probe connection fittings.
      (4) Space for two corrosion coupons with holders.
      (5) Flow meter appropriate for the desired flow range
      (6) Flow control valve

(b) Placement of the corrosion coupon rack shall be at, or as near as possible, to the low point of the system. It shall be placed immediately upstream of the chemical feed injection point and shall receive the "chemically oldest" water of the system. The inlet shall be from the bottom of the corrosion coupon rack. The owner shall have the right to increase the number of coupon ports and the number of corrosion coupon racks.

(c) Corrosion coupons will be analyzed by the water treatment company responsible for those coupons and test reports provided at recommended intervals.

(d) Corrosion coupons may also be installed and analyzed by the Owner's representatives as a control on the water treatment company.

C. Chemical Treatment - Hot Water Closed Heating System with Glycol

1. In addition to the above, provide sufficient inhibited glycol for a 40% solution in the closed water system. This material shall be of a grade suitable for cooling and refrigeration systems. Automotive grade glycol is not to be used for this application. HVAC grade Dowtherm 5R-1 or equal shall be acceptable.

   HVAC grade glycol contains a complete corrosion inhibitor package and can be purchased as neat product and diluted into the system, or for small systems, it may be more convenient to purchase a ready mixed grade that can be used to fill the system without further dilution.

2. Provide a manual feed pump to introduce glycol into the system. Pump shall feed glycol from the drum with minimum capacity of 60 gph (1.0 gpm) for system pressure. Drum cradle with flexible suction and discharge hose minimum 10 ft. shall be supplied. Mechanical contractor to install hose cock at point of injection.

D. Chemical Treatment - Chilled Water Closed System

1. The water treatment company shall provide a suitable water treatment program for Chilled Water Closed Systems. The program shall meet the performance requirements, as outlined above.

2. Provide a 5 gallon shot feeder including funnel, or 2" wide mouth valve opening and air relief valve for addition of chemicals to the system. Isolation valves and a low point drain shall be included in this piping system.

3. Chemical feed pumps, positive displacement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and discharge capacity to meet system requirements.

4. The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the controller and pump.

5. Coupon Rack

(a) Furnish and install in addition to corrosion spool pieces, a coupon rack to monitor chemical treatment. Coupon rack to be fabricated from 1 inch diameter black iron pipe. Do not combine coupon rack with spool piece assembly. The coupon rack shall include, as a minimum:
(1) Inlet and outlet shut-off valves and low point drain.
(2) Wye strainer.
(3) Corrosion probe connection fittings.
(4) Space for two corrosion coupons with holders.
(5) Flow meter appropriate for the desired flow range.
(6) Flow control valve.

(b) Placement of the corrosion coupon rack shall be at, or as near as possible, to the low point of the system. It shall be placed immediately upstream of the chemical feed injection point and shall receive the "chemically oldest" water of the system. The inlet shall be from the bottom of the corrosion coupon rack. The owner shall have the right to increase the number of coupon ports and the number of corrosion coupon racks.

(c) Corrosion coupons will be analyzed by the water treatment company responsible for those coupons and test reports provided at recommended intervals.

(d) Corrosion coupons may also be installed and analyzed by the Owner's representatives as a control on the water treatment company.

E. Chemical Treatment - Chilled Water Closed System with Glycol

1. In addition to the above, provide sufficient inhibited glycol for a 40% solution in the closed water system. This material shall be of a grade suitable for cooling and refrigeration systems. Automotive grade glycol is not to be used for this application. HVAC grade Dowtherm 5R-1 or equal shall be acceptable.

HVAC grade glycol contains a complete corrosion inhibitor package and can be purchased as neat product and diluted into the system, or for small systems, it may be more convenient to purchase a ready mixed grade that can be used to fill the system without further dilution.

2. Provide a manual feed pump to introduce glycol into the system. Pump shall feed glycol from the drum with minimum capacity of 60 gph (1.0 gpm) for system pressure. Drum cradle with flexible suction and discharge hose minimum 10 ft. shall be supplied. Mechanical contractor to install hose cock at point of injection.

3. Coupon Rack

(a) Furnish and install in addition to corrosion spool pieces, a coupon rack to monitor chemical treatment. Coupon rack to be fabricated from 1 inch diameter black iron pipe. Do not combine coupon rack with spool piece assembly. The coupon rack shall include, as a minimum:

(1) Inlet and outlet shut-off valves and low point drain.

(2) Wye strainer.

(3) Corrosion probe connection fittings.

(4) Space for two corrosion coupons with holders.

(5) Flow meter appropriate for the desired flow range.

(6) Flow control valve.

(b) Placement of the corrosion coupon rack shall be at, or as near as possible, to the low point of the system. It shall be placed immediately upstream of the chemical feed injection point and shall receive the "chemically oldest" water of the system. The inlet shall be from the bottom of the corrosion coupon rack. The owner shall have the right to increase the number of coupon ports and the number of corrosion coupon racks.

(c) Corrosion coupons will be analyzed by the water treatment company responsible for those coupons and test reports provided at recommended intervals.

(d) Corrosion coupons may also be installed and analyzed by the Owner's representatives as a control on the water treatment company.

1.8 CHEMICAL TREATMENT FEED AND CONTROL

A. Chemicals shall be supplied in bulk consistent with established safety guidelines. The Supplier shall supply all equipment required to properly feed the chemical programs and to control system operations in the ranges recommended by the Supplier for optimum performance.

B. The chemical feed and control system shall be supplied by the water treatment vendor and shall be designed to feed chemicals to the condenser water system based on blowdown (conductivity control) or make-up (water meter control) as recommended by the water treatment vendor and approved by the Owner or his representative.

With either system, the controller shall provide grounded AC receptacles for chemical treatment pumps and switched for automated or manual control of chemical feed and blowdown.

When chemicals additions are taking place, the system shall be under normal circulation conditions.

C. Air Conditioning Condenser Water System (Automatic Water Treatment Control System Without Acid Feed Less Than 100 ppm of Total Alkalinity in Make-up Water)

1. Chemical feed shall be accomplished from the low point of the system. Each chemical shall be fed from a mechanical pump which is suitable for the maximum building pressure where it is installed. Each pump shall be on an automatic controller, based on a: system make-up water demand, or b: chemical demand.

2. The water treatment chemical(s) shall be fed downstream of all sampling and corrosion coupon sample ports. The high pressure chemical feed line(s) into the building system shall be as short as possible and shall feed directly into a continuously circulating condenser water line. The positioning of these feed lines shall be such that the chemicals do not contact each other before they enter the building system. Appropriate check valves and control valves shall be installed to preclude back feeding of one chemical into another and to allow easy disassembly of the mechanisms.

3. Control panel shall be a single NEMA 12 steel enclosure, primed and painted, and shall have the following basic features, fully pre-wired.

   (a) Internal wiring harnessed, color coded, clearly identified and brought to master terminal board.

   (b) Grounded AC receptacles for chemical treatment pump and utility use.

   (c) Main power switch and indicating lamp with door to shut off line voltage to control when adjustment or maintenance is required.

   (d) Manual/Off/Auto selector switch and indicating lamp for bleedoff valve control.

   (e) A selector switch for control of chemical feed from metered make-up or conductivity controller.

   (f) Manual/Off/Auto selector switch for chemical treatment pump control.

   (g) Conductivity controller with indicating meter.

   (h) A counter and timer pulsed from a water meter with electric contactor in the make-up water supply line shall operate the chemical treatment pump to maintain the proper proportion of chemicals.

   (i) One pre-wired programmable timer shall be available for controlling the feed of two biocide feed pumps.

(j) The TDS (Total Dissolved Solids) shall be monitored and controlled by a voltage regulated, linear conductivity controller. The conductivity controller shall be fully transistorized with plug-in printed circuit boards. The controller shall be linear over its full measuring range of 100 to 6,000 micromhos and shall have a built-in 20-amp heavy duty relay. Power and bleedoff status shall be displayed by indicating lights on the front panel. The controller shall be insensitive to phase angle shifts and be capable of operating with input line voltage of 95 to 130 volts, AC, without affecting accuracy.

(1) Sample stream piping assemblies, each shall be prepiped, and shall consist of one (1) conductivity probe with dual carbon elements potted in a PVC holder, mounted in a Flo-Tee, three (3) chemical injection tees, check valves, sample cock and inlet and outlet shut-off valves.

(2) Chemical feed pumps, positive displacement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and discharge capacity to meet system requirements.

(3) The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the control panel.

(k) Alarm - audible and visual alarm actuated on low or high pH is exceeded. Forced bleed until low or high pH condition is corrected.

(1) Alarm silence button.
(2) Front panel fuses.
(3) One pre-wired programmable timer shall be available for controlling the feed of two biocide feed pumps with bleed lockout.

4. Air Conditioning - Condenser Water System (Automatic Water Control System With Acid Feed; Greater Than 100 ppm of Total Alkalinity in Make-up Water)

(a) Chemical feed shall be accomplished from the low point of the system. Each chemical shall be fed from a mechanical pump which is suitable for the maximum building pressure where it is installed. Each pump shall be on an automatic controller, based on a: system make-up water demand, or b: chemical demand.

(b) The water treatment chemical(s) shall be fed downstream of all sampling and corrosion coupon sample ports. The high pressure chemical feed line(s) into the building system shall be as short as possible and shall feed directly into a continuously condenser water line. The positioning of these feed lines shall be sure that the chemicals do not contact each other before they enter the building system. Appropriate check valves and control valves shall be installed to preclude back feeding of one chemical into another and to allow easy disassembly of the mechanisms.

(c) Control panel shall be a single NEMA 12 steel enclosure, primed and painted, and shall have the following basic features, fully pre-wired:-

(1) Internal wiring harnessed, color coded, clearly identified and brought to master terminal board.

(2) Grounded AC receptacles for chemical treatment pump and utility use.

(3) Main power switch and indicating lamp with door to shut off line voltage to control when adjustment or maintenance is required.

(4) Manual/Off/Auto selector switches and indicating lamps for bleedoff control, chemical feed and acid feed with legend plates.

(5) A counter and timer pulsed from a water meter with electric contactor in the make-up water supply line to operate the chemical treatment pumps.

(6) A selector switch for control of chemical feed from metered make-up or pH controller.

(7) Conductivity controller with indicating meter.

(8) The TDS (Total Dissolved Solids) shall be monitored and controlled by a voltage regulated, linear conductivity controller. The conductivity controller shall be fully transistorized with plug-in printed circuit boards. The controller shall be linear over its full measuring range of 100 to 6,000 microhms and shall have a built-in 20 amp heavy duty relay.

Power and bleedoff status shall be displayed by indicating lights on the front panel. The controller shall be insensitive to phase angle shifts and be capable of operating with input line voltage of 95 to 130 volts, AC, without affecting accuracy.

5. The pH controller shall be an integral part of the control panel an it, too, shall be front panel mounted. It shall have these features:-

Input range	0 - 14 pH
Input Impedance	Greater than 10^{13} ohms
Output	0- 10 volts
Stability	Less than 0.001 pH/week
Line voltage effect	0.001% change
Limit of error	Output - 1% of full scale
Limit of error	Meter - 2% of full scale
Response time	1 sec. for 90% of change for typical electrode system regardless of length of transmitter cable
Input bias cable	Less than 10^{12} amps 25°C
Avg. Temperature coeff	0.001 pH per °C
Humidity effects	Negligible at 99% relative humidity
Ambient temperature	40°F to 140°F
Temperature compensation	Automatic of fixed only
Alarm per control	Single pole, single throw high or low mode-field selectable.
Contact rating	120 VAC 5 amps res.
Power requirements	90 - 132 VAC/60Hz/12 watts

6. The pH controller shall be voltage regulated and fully transistorized with adjustable High/Low contacts and indicating lamps. The controller shall be linear over its full measuring range of 0 - 14 pH. A Manual/Off/Auto selector switch indicating lamp and feed limit timer shall be provided for acid pump control, pH shall be recorded on a strip recorder.
7. When the pH of the system falls below the pH set point, the controller shall be interlocked with bleedoff valve open, the inhibitor feed pump on, the acid feed pump off and the low pH alarm on, until the situation is corrected.

8. The pH probe shall have a remote pre-amplifier coupled with it to insure that the length of the transmitter cable does not affect the response time of the accuracy of the system.

9. The chemical feed shall be controlled by either a reset timer actuated by a make-up water meter with electric contractor, or from the pH controller. The chemical feed control module shall have a pump status indicating lamp, a Manual/Off/Auto switch and a 20-amp pump relay.

10. Sufficient sample stream piping assemblies. Each shall be pre-piped and consist of one (1) conductivity probe with dual carbon elements potted in a PVC holder, mounted in a FloTee, one (1) pH flo-cell with measuring and reference electrodes, four (4) chemical injection tee's one (1) check valve, one (1) flow switch, one (1) sample cock and inlet and outlet shut-off valves.

11. Sufficient chemical feed pumps, positive dis-placement type, with ball-type check valve and feed rate adjustable while pump is running. Each chemical feed pump shall have the necessary pressure rating and PVDC, acrylic, or polyproplyene liquid handling materials with discharge capacity to meet system requirements. The acid pump shall contain the necessary materials of construction to resist corrosion from pumping sulfuric acid. Acid pump shall have 1/4" PVDC discharge connection for schedule 80 PVC piping to system and shall include PVDC acid injection nozzle with shut off valve on condenser water line.

12. The controller, sample stream piping assembly and chemical feed pumps shall be pre-piped, pre-wired, and assembled on a steel wall frame. This prefabricated water treatment system will require the mechanical contractor to provide inlet and outlet water connections and 110/1/60 power to the control panel as well as chemical feed discharge connections and piping to the condenser water line with check valve and shut off valve at each injection point.

1.9 SERVICE PROGRAMS

A. The Supplier shall provide a complete service program to support his chemical treatment program and to protect the building water systems. The Supplier shall visit the building biweekly or as required, and shall be available for emergency service on 24 hours notice.

B. Water Testing by Building Personnel

The Supplier shall provide all field test kits and reagents required for maintaining proper control of chemical additions and operating conditions in the building water and steam systems. The supplier shall provide a Hach DR 2020 or equivalent test unit for use by building personnel. The supplier shall train building personnel in the proper testing procedures and shall supply suitable forms for recording test results. Costs for test equipment and annual costs for reagents shall be specifically identified.

1. Weekly Testing of all Closed Systems, Including Chilled Cooling Water, and Hot Water Heating Systems.

   (a) pH.

   (b) Corrosion inhibitor.

   (c) Bioassay slide (monthly).

   (d) Other tests as required by building management of the Supplier.

2. Daily Testing of Steam

   (a) Codensate pH.

   (b) Other tests as required by building management of the Supplier.

C. Testing by the Supplier

1. The Supplier shall perform independent tests on all water systems twice per month or as agreed with building management. The Supplier's tests shall include all tests run by building personnel plus copper, iron, copper corrosion inhibitor level in cooling systems, and dissolved oxygen in condensate water plus a steam purity check and other tests as needed. The supplier shall compare his results with building test data and prepare a report for building management after each visit. As a minimum, this report shall discuss abnormalities and variations, and highlight any actions needed to maintain good results in all systems. The supplier shall take quarterly water samples from all systems for complete chemical and microbiology analyses.

2. Inspections

(a) All condensers, surface condensers, heat exchangers, and steam systems shall be inspected annually and as available, using fiber optic and ultrasonic test equipment as needed. A photographic record shall be kept of the condition of the tubesheets, heads and accessible piping.

1.10 WATER METER

A. Water meter provided by water treatment company shall be installed on make-up water line to tower. Water meter shall have electric contact head of following size:

Up to 500 tons	3/4"	100 gallon contact
500 - 900 tons	1"	150 gallon contact
900 - 1500 tons	1 ½"	300 gallon contact
1500 - 2000 tons	2"	500 gallon contact
2000 - 3000 tons	3"	750 gallon contact
Over 3000 tons	As recommended by water treatment contractor.	

1.11 CHEMICAL TREATMENT TESTING EQUIPMENT

A. Provide a complete test set with apparatus and chemical reagents for running all control tests required for the condenser water, closed water, open water system and boiler systems, as determined by the water treatment company. The test equipment shall include a wall hung metal cabinet with light, for storage of test reagents and apparatus.

1.12 DIELECTRIC FITTINGS

A. Provide dielectric fitting to isolate joined dissimilar materials to prevent galvanic action and stop corrosion. Fittings shall be of the non reducing type, which shall be suitable for the system fluid, pressure, and temperature and shall not restrict the flow.

1.13 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. As a minimum, the following information must be supplied for each chemical to be used in the building water systems:

1. Product data sheet.

2. MSD sheet.

3. Generic composition.

4. Product dosage, during startup and normal operation.

5. Concentrations of active ingredients in the circulating water.

6. Required operating parameters, e.g. pH and cycles of concentration.

7. Product cost per pound and required pounds per year.

8. Total annual program cost for chemicals, reagents and required analytical equipment.

C. In addition, submit the following for approval:

1. System installation drawings and diagrams.

2. Product information and material safety data sheets on each component, device, pump, controller, valve, etc. being supplied in the system.

3. Analysis of raw water supplying each system. Field test reports indicating and interpreting test results relative to compliance with specified requirements.

4. Product information sheets and MSD sheets on all chemical products being supplied for each system including chemicals. Include manufacturer's technical product data, rated capacities of selected equipment clearly indicated, water-pressure drops, weights (shipping, installed, and operating), furnished specialties, accessories, and installation and startup instructions.

5. Recommended feed rates on each chemical product.

6. Analysis of blow down water from each system requiring blowdown.

7. Recommended quantity of blowdown water from each system requiring blowdown.

8. Recommended operating conditions for each system including cycles of concentration, chemical test limits of water treatment system set points.

9. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

10. Wiring diagrams detailing power and control wiring and differentiating clearly between manufacturer-installed wiring and field-installed wiring.

11. Maintenance data for chemical water treatment to include in the operation and maintenance manual specified in Division 1. Include detailed manufacturer's instructions and parts list for each item of equipment, control, and accessory. Include troubleshooting maintenance guide.

12. Name of Vendor.

1.14 QUALITY ASSURANCE

A. Supplier Qualifications: A recognized chemical water treatment supplier with warehousing facilities in the Project's vicinity and that is or employs an experienced consultant, available at reasonable times during the course of the Work to consult with Contractor, Architect, and Owner about water treatment.

B. Water Treatment Suppliers must have at least five years of experience applying and servicing water treatment programs in similar type and sized buildings in the area the building is located.

C. The water treatment company shall be regularly engaged in this type of work and service. It shall have on its staff a graduate chemical engineer with experience in water treatment Further, this firm shall include the start-up of chemical treatment; instruct the Owner's operating personnel in the performance of control tests and their interpretation and to supervise, through periodic visits, the progress of the water treatment program. Such service shall be provided during construction and for two years after the Owner's acceptance for the facilities.

D. Water Treatment Suppliers must have a laboratory that is equipped and staffed to analyze water and deposit samples in accordance with standard methods. Water treatment supplier must have trained service personnel available to provide year-round service support to the building and respond to any emergency calls.

E. Chemical Standards: Meet state and local pollution-control regulations.

F. Comply with NFPA 70 for components and installation.

G. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

1.15 MAINTENANCE

A. Service Period: Provide chemicals and service program for period of two years from startup date of equipment, including the following:

1. Initial water analysis and recommendations.

2. Startup assistance.

3. Training of operating personnel.

4. Periodic field service and consultation.

5. Customer report charts and log sheets.

6. Laboratory technical assistance.

1.16 EXTRA MATERIALS

A. Chemicals: Furnish quantity equal to 50 percent of amount initially installed.

PART 2 - PRODUCTS

2.1 BIDDERS AND MANUFACTURERS

A. The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Betz Industrial

2. Ashland Chemical Company, Drew Industrial Division

3. Diversey Water Management.

4. Nalco Chemical Company

5. The Metro Group

6. Or engineer approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install treatment equipment level and plumb, according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.

3.2 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 Sections. The following are specific connection requirements:

1. Install piping adjacent to equipment to allow servicing and maintenance.

2. Piping: Conform to applicable requirements of Division 15

B. Electrical: Conform to applicable requirements of Division 16

1. Provide all necessary wiring to an adequate source of electric power and all required interwiring.

2. Install electrical devices furnished with boiler but not specified to be factory mounted.

3.3 FIELD QUALITY CONTROL

A. Testing Agency: Provide the services of a qualified independent testing agency to perform field quality-control testing.

3.4 ADJUSTING

A. Sample boiler water at 1-week intervals after boiler startup for a period of 5 weeks and prepare certified test report for each required water performance characteristic. Where applicable, comply with ASTM D 3370 and the following standards:

1. Silica: ASTM D 859.

2. Steam System: ASTM D 1066.

3. Acidity and Alkalinity: ASTM D 1067

4. Iron: ASTM D 1068.

5. Water Hardness: ASTM D 1126.

6. Particulate and Dissolved Matter: ASTM D 1888.

B. Sample system water for each system at 1-week intervals after startup for a period of 5 weeks and prepare certified test report for each required water performance characteristic.

3.5 CLEANING

A. After completing system installation, including outlet fittings and devices, inspect exposed parts and finish. Remove burrs, dirt, and construction debris; repair damaged finishes, including chips, scratches, and abrasions.

B. At no time shall the Mechanical Contractor add water to a system without a corrosion inhibitor treatment. The addition of minimal quantities of untreated water to a satisfactorily treated system is allowed.

C. Ensure that system is operational, filled, started, and vented prior to cleaning. Place terminal control valves in OPEN position during cleaning. Use water meter to record capacity in each system.

D. Add cleaning chemicals as recommended by manufacturer.

1. Hot-Water Heating System: Apply heat while circulating, slowly raising system to design temperature; maintain for a minimum of 12 hours. Remove heat and allow to cool; drain and refill with clean treated water. Circulate for 6 hours at design temperature, then drain. Refill with clean treated water and repeat until system cleaner is removed.

2. Chilled-Water System: Circulate for 48 hours, then drain. Refill with clean treated water, circulate for 24 hours, then drain. Refill with clean treated water and repeat until system cleaner is removed.

3. Steam System: Fill steam boilers only with cleaner and treated water. Apply heat and maintain for a minimum of 12 hours. Cool and drain. Refill with clean treated water, drain, refill, and check for sludge. Repeat until system is free of sludge. Apply heat to produce steam for piping system and maintain for a minimum of 8 hours. Bypass traps and waste condensate.

4. Open System: Flush with clean treated water for a minimum of one hour. Drain completely and refill.

3.6 COMMISSIONING

A. Startup Services: Provide the services of a factory-authorized service representative to provide startup service and to demonstrate and train Owner's maintenance personnel as specified below.

B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Startup Procedures: During boiler system startup, operate boiler water treatment system (after charging with specified chemicals) to maintain required steady-state characteristics of feedwater.

3.7 REPORTING REQUIREMENTS

A. In addition to the regular service reports specified above. The Supplier shall prepare a quarterly report for building management. This report shall contain a summary of routine test results, corrosion coupon and microbiological tests results, projects, accomplished during the preceding quarter, and specific action recommendations to correct any abnormal conditions in the water systems. The analytical data should be presented in graphical form for easy visualization and recognition of trends. Annual review meetings may also be scheduled by building management as desired.

3.8 DEMONSTRATION

A. Provide services of supplier's technical representative for a full day to instruct Owner's personnel in operation, maintenance, and testing procedures of water treatment systems.

B. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."

D. Schedule training with Owner, through the Architect, with at least 7 days' advance notice.

END OF SECTION 15545

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15550 - HEAT GENERATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes packaged, factory-assembled, fuel fired boilers and accessories utilized for heating systems.

1.2 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section 15010 BASIC MECHANICAL REQUIREMENTS

C. Section 15050 BASIC MECHANICAL MATERIALS AND METHODS

D. Section 15491 FUEL OIL SYSTEM PIPING & STORAGE TANKS

E. Section 15575 BREECHINGS, CHIMNEYS & STACKS

F. Section 15942 VARIABLE FREQUENCY CONTROLLERS

G. This section is a part of each Division 15000 Section.

1.3 REFERENCES

A. ASME.

B. ANSI.

C. NFPA.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in boiler plants with five years minimum experience.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of equipment and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART 2 - PRODUCTS

2.1 BOILER PLANT (HOT WATER), (NATURAL GAS)

A. Boiler Capacity

1. See Plans.

B. General Boiler Design

1. The hot water boiler shall be a four pass horizontal firetube up-draft boiler with five (5) square feet of heating surface per rated boiler horsepower. It shall be mounted on a heavy steel frame with integral forced draft burner and burner controls. The complete packaged boiler shall be approved as a unit by Underwriters' Laboratories and shall bear the Underwriters' "B" label, and shall be equipped as required to comply with standard and local governmental units.

2. The hot water boiler shall be completely preassembled and fire tested at the factory. The unit shall be ready for immediate mounting on floor or simple foundation and ready for attachment of water, fuel, electrical and vent connections.

3. Two-gate pattern, double wedge disc bottom drain valves, Lunkenheimer Fig. #2125 shall be supplied for each boiler.

C. Boiler Shell

1. The boiler shell shall be constructed in accordance with ASME Boiler Code and must receive authorized boiler inspection prior to shipment. A copy of the inspection report shall be furnished to the purchaser.

2. The hot water return and outlet connections shall be located on the top center line of the boiler. The boiler shall be designed to rapidly mix the return water with the boiler water.

3. Provide device to reduce possibility of thermal shock to the boiler vessel. Device shall include circulating pumps to blend boiler water with incoming system water and to provide positive flow across the boiler tube sheets. Device shall be factory installed.

4. A dip tube shall be included as an integral part of the hot water outlet.

5. Two lifting eyes must be located on top of the boiler.

6. Front and rear doors on the boiler shall be hinged or davited. Doors are to be sealed with fiberglass tadpole gaskets and fastened tightly using heavy capscrews which thread into replaceable brass nuts.

7. Rear refractory and insulation shall be contained in the formed rear door which must swing open for inspection of brick work.

8. Front and rear tube sheets and all flues must be fully accessible for inspection and cleaning when the doors are swung open. The shell shall be furnished with adequate handholes to facilitate boiler inspection and cleaning. For boilers over 48 inches diameter, a manhole shall be provided.

9. The exhaust gas vent shall be located near the front of the boiler on the top center line, and shall include tappings for insertion of draft and exit gas temperature sensors.

10. Observation ports for the inspection of flame conditions shall be provided at each end of the boiler, and a combustion explosion relief door shall be included in the furnace path.

11. The boiler insulation shall consist of a 2 inch fiberglass blanket under a sectional preformed sheet metal lagging. This insulation must be readily removable and replaceable, if required.

12. The entire boiler, base, frame, and other components shall be factory-painted before shipment, using a hard-finish enamel.

D. Hot Water Boiler Trim

1. The following items shall be installed on the boiler.

(a) Low Water Cutoff - A low water cutoff probe control shall be mounted in the shell of the boiler. It is to be wired in the burner control circuit to prevent burner operation if the boiler water falls below a safe level.

(b) Miscellaneous - A temperature gauge shall be mounted on the boiler. Temperature controls (for regulation of burner operation) shall be mounted on the boiler and the temperature sensing elements shall be located adjacent to the boiler outlet. Modulator, operating, manual reset high limit, and a low fire hold temperature control shall be included. Water relief valves shall be of a type and size to comply with code requirements. Provide a secondary low water cutout control as a back-up to the primary low water cutoff. Secondary low water cutout shall require manual reset prior to restarting the boiler after a low water condition.

E. Forced Draft Blower

1. All air for combustion shall be supplied by a forced draft blower mounted in the front boiler door, above the burner, to eliminate vibration and reduce noise level. Boiler sound pressure level shall be obtained from tests made in compliance with "ABMA TEST CODE FOR MEASUREMENT OF SOUND FROM PACKAGE BOILERS", and shall be certified by boiler manufacturer to be below OSHA limits, as part of submittals to consulting engineer.

2. The impeller shall be cast aluminum, radial blade, carefully balanced, and directly connected to the blower motor shaft. Blower shall be acoustically lined to maintain minimum sound level.

3. The forced draft blower motor shall be powered through a variable frequency controller connected to the boiler firing rate controls in such a way as to regulate the air flow to the boiler while minimizing the electric consumption of the motor.

4. The Drive's voltage, frequency, and current ratings shall be rated in accordance with the electrical requirements as dictated by the project specifics and for the properly rate motor horsepower.

5. The Variable Speed Controller must be capable of communicating over DeviceNet Protocol.

6. A factory-installed pressure transmitter shall be supplied to measure the Windbox combustion air pressure and shall be capable of supplying a 4..20mA process variable input to the Variable Speed Controller.

7. Variable Frequency controller will be furnished and factory installed by the boiler manufacturer. The VFC shall be as specified under anther section of this work.

F. Burner and Flame Failure Controller

1. The program relay shall control ignition, starting and stopping of the burner and provide both a pre-combustion purge and a post-combustion purge. It shall shut down the burner in the event of ignition, pilot, or main flame failure.

G. Burner & Piping

1. The burner shall be integral with the front head of the boiler and shall be a combination of the low pressure air atomizing type for oil and the high radiant annular entry type for gas. The burner must be approved for operation with either CS-12-48 Commercial No. 2, No. 4 or No. 6 Oil or natural, manufactured, or mixed gas.

2. The burner shall be designed for low NOx emissions using flue gas recirculation. NOx emissions on natural gas shall be 30 ppm or less as corrected to 3% oxygen in the flue gas.

3. Induced flue gas recirculation system shall be provided with control dampers and characterizing devices to maintain required emission levels on all fuels. If external flue gas piping is required, boiler manufacturer is to provide a complete system including all required duct work, insulation, supports and quick disconnect flanges.

4. The burner shall operate on the full modulation principle through electronically characterizable parallel positioning controls. Burner must always return to the low fire position for ignition.

5. The gas pilot shall be the premix type with automatic electric ignition. An electronic detector shall monitor the pilot so that the primary fuel valve cannot open until pilot flame has been established.

6. Combustion air damper and fuel metering valves shall be operated by individual servo motors to regulate the fire according to load demand.

7. An oxygen sensor with heated zirconium oxide sensing cell shall be used to fine tune the fuel to air ratio to maintain optimum fuel to water efficiency at all firing rates and for each fuel.

H. Gas System

1. The gas burner piping train shall be factory equipped per IRI/FIA requirements, and shall include the following components: main gas pressure regulator, two manual lubricated plug shutoff cocks, two normally closed motorized safety shutoff valves, with intermediate normally open solenoid safety shutoff valve, manual test cock, high and low gas pressure switches, butterfly valve, gas pressure gauge. Train shall also conform to requirements of local utility and any government agencies having jurisdiction. Contractor shall install vent line of adequate size from gas train components requiring venting to atmosphere, terminating vent line at a location which will prevent discharge of vent line into building ventilation intakes. Gas installation including vent piping shall be in accordance with all local building codes and with the gas utility company requirements.

I. Control Panel Boiler Management Control System

1. Each boiler shall be factory equipped with a Boiler Control System mounted on the front door of the boiler that is conveniently located for the operator. It shall have a NEMA 12 enclosure and shall have a positive means of locking for security purposes. Boiler Control System shall provide technology and functions equal to the Cleaver Brooks Hawk ICS Boiler Control system.

2. Each Boiler Control System shall be factory equipped with a pre-configured Programmable Controller and Human Machine Interface (HMI). Each control system shall be equipped with a means to manually select the fuel to be burned. Fuel changeovers will require the boiler to be shutdown and re-started on the secondary fuel.

3. Major system components shall include:
   (a) Programmable Controller.

   (b) Touch Screen HMI.

   (c) DeviceNetTM Communication Network Module.

   (d) Various Controller Input/Output Modules.

   (e) One CB 110 / E 300 Burner Management Controllers and Wiring Sub-Base.

   (f) One Flame Scanner: UV Self-Check.

   (g) One Flame Amplifier, to correspond with the selected Flame Scanner.

   (h) Required Temperature Sensors.

4. Major functions that the Boiler Control System shall provide:

   (a) Manual fuel selection input by operator (after burner is shutdown).

   (b) Automatic sequencing of the boiler through standby, pre-purge, pilot flame establishing period, main flame establishing period, run and post purge.

   (c) Flame proving and lockout on flame failure during pilot flame proving, main flame proving, or run.

   (d) Low fire damper/valve position for flame ignition trials.

   (e) Full modulating control of fuel and combustion air.

   (f) Utilize solid state controls and sensors to provide various control functions, such as:

   (g) On/Off, and Modulating Control.

   (h) Modulating Control algorithm shall be Proportional-Integral-Derivative (PID) type.

   (i) Thermal Shock Protection.

   (j) Various High and Low limit alarms and shutdowns.

5. Touch Screen color graphical operator interface and monitoring with the following functions:

   (a) Manual control of the boiler-firing rate utilizing control screens on the HMI to increment and decrement the firing rate.

   (b) On screen indication of burner management controller status and diagnostics.

   (c) On screen real-time display of all connected process parameters.

   (d) On screen display of system alarms and faults.

   (e) On screen history of alarms and faults.

   (f) On screen recommendation for troubleshooting fault conditions.

   (g) On screen water level alarm(s).

6. Interface to Boiler Plant Master Panel via Ethernet LAN.

7. Tamper resistant control logic and password protection.

8. Stack Flue Gas, Combustion Air, and Shell (water) temperatures.

9. Remote Modulation or Firing Rate Set Point control from Plant Master Panel.

10. Assured Low Fire Cut-Off (ALFCO).

11. Terminals shall be provided in panel for remote emergency shutdown switch and for operation of a remote fresh air damper including proof of fresh air damper open prior to boiler ignition.

12. The following points shall be monitored by each Boiler Control System:

    (a) Boiler Hot Water Outlet Temperature
    (b) Boiler Fuel Oil Flow
    (c) Boiler Natural Gas Flow

13. The Boiler Control System shall provide the following safety provisions for:

    (a) Integrated Burner Management
    (b) Examine all load terminals to assure it is capable of recognizing the true status of the external controls, limits and interlocks. If any input fails this test, the burner management system should lockout on safety shutdown.

14. Flame Safeguard controller shall provide technology and functions equal to a Cleaver Brooks model CB110 with E300 Expansion Module. The flame safeguard controller shall be microprocessor based to monitor all critical boiler and burner interlocks, control and supervise burner light-off sequence, and initiate an orderly safety procedure in the event of interlock or flame failure. The entire control system shall comply with IRI and FM insurance requirements and shall be approved by UL. Control system shall be provided completely installed and wired by the boiler manufacturer for single source responsibility.

    (a) Closed-loop logic test verifies integrity of safety critical loads (ignition, pilot, and main fuel valves) and must be able to lockout on safety. shutdown if any safety critical load is identified as proper or improper.

    (b) Pre-ignition interlocks (fuel valve proof of closure, etc.) and flames signal checked during Standby and Pre-Purge.

    (c) Dynamic checking of the flame signal amplifier. The control flame signal amplifier must be able to recognize a no flame signal during this dynamic amplifier check.

    (d) Safe start check and expand check to include monitoring flame signal during standby.

    (e) High and Low fire switches checked for proper sequencing.

    (f) Tamper-proof Purge Timing and safety logic.

    (g) Operating and High Limit Control.

    (h) Primary and Secondary Low Water Cut-Off.

    (i) Variable Speed Drive fault shutdown.

15. Password protection of Programmable Controller logic.

16. Password protection of Parallel Positioning Control.

17. The Boiler Control System shall provide annunciation and diagnostics:

    (a) First out annunciation, plus time and cycle, in sequence of fault occurrence.

    (b) Indication of failures at start up or during normal operation.

    (c) Provide historical alarm information for on screen display or printout.

    (d) Detects and isolates an alarm, and reports internal circuit faults.

    (e) English text description of the system fault and troubleshooting procedures.

    (f) Water Level alarms and/or indication.

18. The Boiler Control System shall be able to operate in these environmental conditions.

    (a) Supply Voltage: 120vac (+10%/-15%) 50 or 60 Hz.

    (b) Maximum total connected load:2000 VA.

    (c) Operating temperature limits: 32 to 130 F

    (d) 85% RH continuos, non-condensing, humidity.

    (e) 0.5G continuos vibration.

19. All Boiler Control System wiring shall be in accordance with the National Electrical Codes and local electrical codes.

20. The control panel shall be mounted on the front door of the boiler and shall be conveniently located for the operator. It shall be a Nema 1A enclosure and it must have a Yale cabinet key lock.

21. The panel shall contain the electronic programming relay, blower motor starter, and control switches. A manual-automatic selector switch and a damper motor positioning switch shall be provided. These switches shall permit automatic firing in accordance with load demand, or manual control of the firing rate at any desired point between low fire and maximum rating.

22. Furnish a lead/lag temperature controller which will permit selection, sequencing, and alternating of boilers. Controller shall be housed in NEMA 1 enclosure, and shall include indicator lights & selector switch. Control shall respond to lead and lag temperature regulators installed in common hot water discharge header downstream of last boiler.

J. Efficiency Guarantee

1. The boiler must be guaranteed to operate at a minimum fuel to water efficiency of 84 per cent 25% to 100% of rated capacity.

K. Shop Tests

1. The packaged boiler must receive factory tests to check the construction, controls, and operation of the unit. All tests may be witnessed by the purchaser, if desired. A copy of the shop testing including a signed copy of the certified hydrostatic test results shall be sent to the customer.

L. Starting Service

1. After boiler installation is completed, the manufacturer shall provide the services of a field representative for starting unit and training the operator.

PART 3 - EXECUTION

3.1 PREPARATION

A. Not applicable.

3.2 INSTALLATION

A. General Gas Fired Unit Notes

1. Unit heaters, durnaces, or other types of gas fueled equipment furnished under this section shall be complete with controls and regulators that are compatible with the type and pressure of the gas furnished to the equipment.

2. Verify that the suppliers or manufacturers of the components comply with the above and also with local codes and jurisdictions.

3. The gas boiler(s) will operate at (7") inches of water column (verify with manufacturer). The gas pressure available at the inlet to the regulator will be a minimum (7") inches of water column and a maximum of (2") PSIG.

4. Provide pressure regulators to control gas pressure at main and pilot gas trains.

5. Install all products as per manufacturer's instructions.

3.3 SCHEDULE

A. As described under "Products."

END OF SECTION 15550

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15591 - FUEL OIL SYSTEM PIPING AND STORAGE TANKS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes piping, specialties, and accessories for fuel oil systems including fuel oil storage tanks.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. This section is a part of each Division 15000 Section.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

A. Minimum Working-Pressure Ratings: Except where otherwise indicated, minimum pressure requirements are as follows:

1. Oil Piping and Fittings: 250 psig (1725 kPa).

2. Underslab, Containment-Conduit Piping: 175 psig (1200 kPa).

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data including size, dimensions, rated capacity, pressure rating, settings, and operating characteristics of selected models, for the following:

1. Each type and size of fuel oil transfer pump.

2. Each fuel oil system specialty.

3. Special-duty valves.

4. Containment-conduit piping system.

5. Fuel oil tanks - size, construction data, tapping connections and locations, details of anchoring and hold down straps.

6. Fuel oil leak detection system, all components, wiring diagrams and manufacturer's literature.

C. Coordination Drawings for fuel oil piping, storage tanks, including required clearances and relationship to other services for same work areas.

D. Wiring diagrams detailing wiring for power, signal, and control systems for each item of equipment with electric power supply and differentiating between manufacturer-installed and field-installed wiring.

E. Test reports specified in "Field Quality Control" Article in Part 3.

F. Maintenance data for fuel oil specialties and special-duty valves to include in the operation and maintenance manual specified in Division 1 Section "Contract Closeout."

1.5 QUALITY ASSURANCE

A. Comply with NFPA 30, "Flammable and Combustible Liquids Code," and NFPA 31, "Installation of Oil Burning Equipment," for fuel oil piping materials, components, installations, inspection, and testing.

B. Comply with NFPA 70, "National Electrical Code," for electrical connections between wiring and electrically operated control devices.

C. Provide listing/approval stamp, label, or other marking on equipment made to specified standards.

D. Listing and Labeling: Provide equipment and accessories specified in this Section that are listed and labeled.

1. Terms "Listed" and "Labeled": As defined in National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

E. Product Options: Drawings indicate size, profiles, connections, dimensional requirements, and characteristics of fuel oil piping equipment, specialties, and accessories and are based on specific types and models indicated. Other manufacturers' equipment and components with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Comply with manufacturer’s recommendations for handling and storing tanks.

B. All shipping and transportation permit costs shall be borne by this contractor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Gate, Globe, and Check Valves:

   (a) Conbraco Industries, Inc.; Apollo Div.
   (b) Grinnell Corp.
   (c) Milwaukee Valve Co., Inc.
   (d) Stockham Valves & Fittings, Inc.

2. Ball and Butterfly Valves:

   (a) DeZurik.
   (b) Neles-Jamesbury, Inc.

3. Fuel Oil Transfer Pumps:

   (a) Preferred Utilities Manufacturing Corp.
   (b) Viking Pump, Inc.
   (c) Webster Heating.

2.2 PIPES AND TUBES

A. All piping shall be steel with welded fittings (galvanized pipe and fittings are not permitted).

B. Steel Pipe: ASTM A 53; Type S, seamless; Grade B; Schedule 40; black.

2.3 PIPE INSULATION

A. As specified under another section.

2.4 PIPE AND FITTINGS

A. All piping shall be provided with ground joint unions at piece of apparatus to facilitate connecting and disconnecting.

B. All horizontal fuel oil piping, within the building shall be installed in a minimum 10 ga. conduit and completely encased with an approved two (2) hour (minimum) fire rated enclosure. All vertical fuel oil piping runs shall be installed in a four (4) inch masonry or concrete shaft.

C. Fuel oil piping, where buried underground, shall be A-120 or A-53 Schedule 80 ERW with extra heavy galvanized malleable iron screwed fittings or extra heavy welded fittings, and shall be field painted with asphaltum. Use of a factory applied coating equal to X-TRU coat as manufactured by General Steel Industries is also permissible. Piping shall be provided with cathodic protection.

D. Steel Fittings: ASTM A 234 (ASTM A 234M), welded, for welded joints.

E. Steel Flanges and Flanged Fittings: ASME B16.5.

F. Unions: ASME, Class 300, malleable iron with brass-to-iron seat, ground joint, and threaded ends conforming to ASME B1.20.1.

G. Transition Fittings: Type, material, and end connections to match piping being joined.

2.5 JOINING MATERIALS

A. Common Joining Materials: Refer to Division 15 Section "Basic Mechanical Materials and Methods" for joining materials not included in this Section.

B. Gaskets for Flanged Joints: Full faced for cast-iron flanges and ring type for steel flanges. Select materials that suit service of piping in which gasket is installed and is not detrimentally affected by chemical and thermal conditions of fuel oil.

2.6 PIPING SPECIALTIES

A. Pipe Connectors: UL 567, swivel or compression type for connection to equipment.

B. Strainers: Y pattern, full size of connecting piping. Include stainless-steel screens with 3/64-inch (1.2-mm) perforations, except where other screens are indicated.

1. Pressure Rating: 250-psig (1725-kPa) WOG working pressure.
2. 2-Inch NPS and Smaller: Bronze body.
3. 2-1/2-Inch NPS and Larger: Cast-iron body.
4. Screwed screen retainer with centered blow-down and pipe plug.

C. Refer to Division 15 Section "Vibration Control" for flexible pipe connectors.

2.7 VALVES

A. General: All valves shall be rated for a minimum of 250 psig WOG working pressure.

B. Valves shall be as specified under another section of Division 15000.

2.8 SPECIALTY VALVES

A. Oil Safety Valves: UL listed for flammable or volatile liquids, 250-psig (1725-kPa) working pressure, and 550 deg F (288 deg C) operating temperature. Include ASTM B 61 bronze body, bronze bases and discs; and field-adjustable, cadmium-plated, carbon-steel springs; factory set at 20 percent above operating pressure; and threaded ends conforming to ASME B1.20.1.

B. Provide and install on the tank suction stub a bronze, 1-1/2" Double Poppet Foot Valve, with lapped-in seat, double guided poppet stems and 20 mesh monel screen. Double Poppet Foot Valve shall be as supplied by Preferred Utilities Manufacturing Corporation, Model Type 22. The foot valve shall come with a 233-FV foot valve extractor fitting which shall allow for easy access to and repair of the foot valve. The 233-FV foot valve extractor fitting shall come with an extractor wrench of the appropriate size.

2.9 FUEL OIL TRANSFER PUMPS AND PIPING

A. Provide a duplex fuel oil pump and piping system as scheduled and detailed on drawings. The set shall be piped and wired, with components mounted on a steel base support fabricated of 1/4" steel plate with 4" steel side rails continuously welded to the base. The base support to be fabricated with 2-3/4" overflow containment lip and base shall extend beyond any fitting, valve, pump, strainer or selector valve. Any fuel leaking from any component, fitting or packing in the system shall be contained by this baseplate. Base shall be grouted and anchored in the field to the housekeeping pad to minimize vibration and movement. In the Rupture Basin through a 3/4" welding boss, shall be a Preferred Utilities Manufacturing Corporation RBS switch for leak detection. Switch shall be redundantly sealed against vapors and fluids, be lever float operated and magnetically actuated. Wiring enclosure shall be cast aluminum and constructed to NEMA 4 standards. Visual and audible alarm and annunciation for the pump set rupture basin shall be located on the pump set control cabinet. Provide a ½: plugged drain connection in the Rupture Basin.

B. Description: UL 343, single-stage, internal-gear, positive-displacement, rotary type. Include foot-mounted, cast-iron housing; steel gears; bronze bearings; steel shaft; mechanical seals; built-in pressure relief bypass; steel base; and drive coupling.

1. Drive: Direct drive, close coupled.

C. Motor: Split phase for single-phase motors; capacitor start, induction run, totally enclosed for 3-phase motors.

D. The pumps shall be connected to the piping in the set through stainless steel flexible metallic metal jackets, and the pump and motor assemblies shall be mounted to the base plate via elastomeric vibration isolators. Pumps and motors shall be mounted on a structural steel channel and equipped with flexible coupling and full OSHA approved coupling guard. Pumps and motors shall be removable for ease of maintenance.

Flexible coupling general: The pumps shall be connected to the motor by an elastomeric jaw type flexible coupling that does not require lubrication. The coupling wear member shall be replaceable without disturbing the alignment of either the pump or motor. Sizing of the flexible coupling shall be based on motor horsepower and rpm. Materials of construction: The coupling body shall be sintered iron and case iron. The elastomeric wear member shall be NBS rubber.

E. Provide a time delayed flow sensing switch on the discharge of the pumpset to bring on the lag pump should the lead pump fail to maintain flow in the loop. Switch will be wired back to the main control cabinet for alarm and annunciation.

F. Furnish and install a complete system of piping with all necessary valves between the system components. Provide a swing check valve and gate valve at the pump inlet. Provide approved anti-syphon valve at high points of suction line. Install fusible link valve on oil supply immediately adjacent to point where pipe generator room in accessible location. Valve shall have provision to close manually (Preferred or equal). Install whatever additional valves may be required by local or state regulations.

2.10 OIL FILL LINES & VENT TERMINALS

A. Vent pipe line shall be provided from the fuel oil storage tank to the required height within building construction and shall terminate with a vent set in masonry. Fitting shall be one piece. Each oil tank vent pipe terminal shall be provided with a weatherproof vent head the approved equal of "Preferred Junior Vent Protector with Screens."

B. Fuel oil fill line shall be provided from the fuel oil storage tank within the building property line terminating with a fill box. Fuel oil fill box shall be EPA and local code approved. Fuel oil fill box shall include cover and spill containment cap. Provide remote overfill alarm bell and light with tank mounted sensor.. Fuel oil fill box shall be manufactured by EBW or approved equal.

C. Each fill and vent terminal shall be provided with approved identification indicating the tank number with which it is connected.

2.11 CATHODIC PROTECTION FOR THE UNDERGROUND FUEL OIL PIPING

A. General

1. The cathodic protection system shall meet all applicable standards and particularly the National Association of Corrosion Engineering RP-01-69 (Rev. 76). Submittal drawings, technical data and field survey reports shall be submitted by the contractor to the engineer for approval. Provide all wiring. The cathodic protection system shall provide a flow of direct current from sacrificial anodes to the outer surface of the F.O. piping, the fill piping, and the vent piping. The cathodic protection system shall be designed on the earth resistivity and earth chemical analysis at the proposed depth of the pipe system. The number and size of sacrificial anodes shall be sufficient for a minimum 30 year life. The system shall be Advanced C.P. System Corporation or engineer approved equal.

B. Soil Resistivity Survey

1. A soil resistivity survey shall be performed. An average soil resistivity shall be used to calculate the number of anodes required to protect the conduits for 20 years.

C. Installation

1. An underground oil piping shall be wirebrushed and coated with two layers of Bitumastic #50 or equal.
2. The anodes are to be installed to provide a minimum of thirty years useful life.
3. All thermoweld connections of anode wires or test station wires shall be checked to insure that the connection is firmly made. Any remaining slag should be removed, wirebrushed and the area recoated with Butumastic #50 or equal.
4. Suitable dielectric gaskets, sleeves and washers are also provided to isolate all new piping systems as required by the specifications.

5. Anodes shall be located 2'-3' away from the pipe to be protected and approximately level with the bottom portion of the pipe.

6. All wires shall be protected from breaking during the backfilling operation. In addition, all backfill shall be free of rocks, stones or other foreign objects which might damage the anodes, wires or pipe coating.

7. Before backfilling, each anode shall be wet with approximately 5 gallons of clean water to insure prompt activation of the anode. Rain or ground water in the ditch will also suffice for this purpose.

8. All anodes and test stations shall be checked after installation by the contractor's corrosion specialist engineer.

9. Upon completions of backfilling, the corrosion specialist engineer will check the pipe/soil and anode potentials and current output. This data will be presented in the final report.

D. Test Stations

1. Test stations shall be provided for each piping run. Test stations shall have a minimum of 1'-6" of slack lead wire. Test leads shall be housed in electrical conduit and terminated in waterproof junction boxes fastened to a building or other accessible structure.

E. Final Report

1. The system shall be tested by corrosion specialist after installation has been completed and backfilled, and a report submitted to the engineer. The soil resistivity survey pipe-to-soil readings and anode current output shall be included in the report.

2. The system under this section of the specifications shall be guaranteed for a period of one year from date of acceptance thereof. Upon receipt of notice of failure of any part of the system, during the guaranty period, the affected part or parts shall be replaced promptly with new parts by and at the expense of the contractor.

2.12 FUEL OIL TANKS - OIL STORAGE BURIED

A. Furnish and install Double-Wall Fiberglass Underground Fuel Storage Tank. See plans for tank capacity. Tank to be Fluid Containment Model DWT -6 Type II ____ _____.

B. The tanks shall be constructed, tested and installed in accordance with NFPA recommendations and shall be furnished with Underwriters' label.

C. The excavation, backfill and foundation will be furnished under another section of the specification. This contractor shall furnish enclosures, covers and frames. The tank shall be tested and installed with pea gravel of approved alternate backfill material according to the current installation instructions provided with the tank.

D. Loading Conditions - Tank shall meet the following design criteria:

1. External hydrostatic pressure. Buried in ground 7' of overburden over the top of the tank. The hole fully flooded and a safety factor of 5:1 against general buckling.

2. Surface loads: When installed according to manufacturer's installation instructions and a review by project structural engineer, tanks will withstand surface H-20 axle loads (32,000 lbs/axle). Note: For non traffic areas, a minimum of 4' of overburden over the top of the tank shall be required.

3. Internal load: Primary tank and annular space shall withstand pressure test of 5 psi. Resulting in a 5 to 1 safety factor.

4. Tanks shall be designed to support accessory equipment such as heating coils, ladders, drop tubes, etc. when installed according to manufacturer's recommendations and limitations.

E. Product Storage Requirements:

1. All primary tanks must be vented. Tanks are designed for operation at atmospheric pressure only, except for use with vapor recovery systems providing the pressure or vacuum does not exceed 1 psi.

2. Tanks shall be capable of storing liquids with specific gravity up to 1:1.

3. Maximum temperature. Tanks shall be capable of storing diesel fuel at temperatures not to exceed 150 deg. F. at the tank interior surface.

4. Tanks shall be chemically inert to petroleum products.

F. Annular Space

1. Tank shall have a space between the primary and secondary walls to allow for the free flow and containment of all leaked product from the primary tank.

2. Tank shall be designed to provide monitoring capability as noted:

(a) Accessibility to the tank bottom between the primary and secondary walls at both ends of the tank.

(b) Tank shall be compatible with a liquid head pressure-type monitor to continuously monitor the primary and secondary tanks. Maximum head pressure is seven feet over tank top.

(c) Liquid media under pressure (contractor provided) shall be used to monitor the interstitial space for tightness.

A mixture of water and anti-freeze agent shall be selected by the tank Owner's representative.

3. Accessories

(a) Anchor Straps - provide glass fiber-reinforced plastic anchor straps for tank. Number and location of straps shall be as specified by manufacturer.

(b) Straps shall be standard as supplied by the tank manufacturer.

(c) Certification Plate - Underwriters' Laboratory label shall be permanently affixed to each tank.

(d) One (1) Carbon Steel Ladder shall be supplied by the tank manufacturer attached to the tank bottom with FRP mounting lugs and wear plate. Refer to drawing for location.

(e) Wear plates shall be provided at base of all internal piping and base of ladder. Each wear plate must be constructed of 10 gauge or thicker steel and must cover an area of at least 144 square inches.

G. Leak Detector Monitor:

1. A Hydrostatic Pressure Monitor which continuously monitors both the inner and outer walls of this Double Wall Tank shall be furnished. A fiberglass reservoir, integrally constructed with the tank, shall be surface mounted on the tank top.

H. The tanks shall be set on concrete foundations and anchored with fiberglass hold down straps as recommended by the manufacturer. Each strap shall be capable of withstanding the bouyancy load for the tank diameter.

I. Performance Warranty:

1. Tank manufacturer shall furnish a warranty stating as follows:

(a) We warrant that our underground tanks if installed underground with proper backfill and otherwise installed in accordance with our instructions:

(1) Will meet our published specifications and will be free from material defects in materials and workmanship for a period of one (1) year following date of original shipment;

(2) Will not fail for a period of thirty (30) years from date of original shipment due to external corrosion;

(3) Will not fail for a period of thirty (30) years from date of original shipment due to internal corrosion, provided the tank is used solely for oil at temperatures not to exceed 150°F.

(4) Will not leak for a period of thirty (30) years from date of original purchase due to structural failure (defined as breaking or collapse) provided the installation is performed and validated by a qualified installation contractor and the tank is used as stated above.

J. Underground Installation

1. Replace all excavated native soil with approved backfill per manufacturers installation instructions.

2. Underground tanks shall be set on a 18" reinforced concrete slab covered with 12" of pea gravel as shown on drawings. The use of saddles or "chock blocks" or any sort is not permitted. The excavation shall be de-watered during installation and backfill operations. The backfill shall be placed in 6" layers, each layer tamped with hand-guided power equipment. Excavation material used for backfill must be capable of being 95% compacted.

3. Tanks shall be covered as shown on drawings but not less than a minimum of 4 feet of pea gravel.

4. Tanks shall not be filled or partially filled during their installation.

5. Precautions shall be observed to anchor the tank in place.

6. Excavation shall include the removal of all materials such as rock, boulders, concrete and any other materials encountered in the installation of the work under the contract. Excess material shall be removed from the premises.

7. All necessary sheeting and shoring for, and pumping of water from excavation for this work shall be done and after inspection and approval of the work installed, all sheeting and shoring shall be removed, and excavations shall be refilled with clean earth, thoroughly tamped.

2.13 FUEL OIL TANK INFORMATION PANEL SYSTEM

A. Level Gauging:

1. Provide and install a Storage Tank Liquid Level Management System. Third party tested 0.1 gph In-Tank and or external 0.2 gph Out-of-Tank Detection capabilities which meet and exceed the current standard EPA required protocols. Console shall include integral printer.

B. Leak Detection: (Hydrostatic)

1. The tank shall be supplied by the manufacturer with a brine solution in the annular space blended to provide freeze protection to -40°F. In event that the reservoir totally drains, the control panel alarm will be activated - the warning light will illuminate, the alarm horn will sound and the transmission contacts will activate any accessory alarm devices.

2. The alarm horn can be temporarily silenced by pressing the reset button. Under this condition, the “LEAK” light is illuminated. After refilling the reservoir, the “LEAK” light is off and the control panel is restored to the operational mode.

C. Liquid Head Pressure Monitoring Reservoir:

1. The primary function of a tank monitor is to detect a breach in the inner or outer tank under all circumstances. A pressure type system fulfills this criteria, and a continuous leak detector system, which works on the principle of liquid head pressure, shall be furnished for each tank.

2. In the event of an inner tank leak, the liquid media in the cavity (the space between the two walls of the tank) flows into the inner tank, thereby preventing any stored product from escaping from the inner tank, into the cavity. In event of outer wall breech, system liquid media flows to tank excavation.

2.14 CONTROL UNITS

A. For One or Two Tank Installation - provide and install:

1. Controller: The controller shall be microprocessor-based, and shall be designed and constructed with modular architecture easily permitting either factory or field upgrades and servicing. Configuration and set-up data shall be maintained in non-volatile memory having a minimum fifty (50) year data retention without requiring power of any kind. Replacement or substitution of any controller plug-in card shall not require system re-configuration. Real-time clock and non-critical log data, such as inventory, delivery, alarm, theft, error, and leak reports shall be maintained in battery backed non-volatile memory with a minimum data retention of from (5)-(10) years in the event of a power outage. System shall include digital display for viewing tank information and LED indicators for the alarm conditions.

2. System shall have the capability to continuously monitor up to two (2) dual-float magnetostrictive in-tank level probes and up to eight (8) discrete external leak sensors. The system shall provide hardcopy 24 column environmental compliance reports which exit the front panel or are stored internally with optional autowinder take-up spool. The RS-232 serial port shall be standard for communications with a local PC computer. Optional internal modem shall be available for secure telephone link access to the remotely located PC. Optional Fax/Modem shall be available for secure telephone link access to support class 2 fax transmissions. System shall operate on switch selectable 110/220 VAC(+/- 10%), 50/60 Hz. Maximum power consumption shall be less than 20 watts.

(a) Console: The console shall be housed in a lockable wall mounted NEMA 12 enclosure and optionally available in NEMA 4 or 4x outdoor configurations. A printer option with autowinder shall be available for the outdoor versions. The console shall include microprocessor board, probe/sensor card, power supply, control I/o and communications interfaces. Front panel display shall include audible and visual alarms, user friendly pushbutton controls, and optional impact printer. The display shall be nine digit, seven segment , quasi-alphanumeric super bright LED type, with LED alarm annunciators for five (5) alarm conditions; leak, three (3) tank product setpoints, and one (1) bottom water setpoint per tank. LED alarm lights shall be visible from at least 60 feet and the seven

segment display data shall be readable from no less than twenty (20) feet. Displays shall include product gross or net, percent of capacity, 90% ullage, product and water level, product temperature, and product type. As a standard, two (2) relay outputs and two (2) contact closure inputs shall be provided. Optionally, a modular card containing an additional four (4) relays and four (4) contact closure inputs shall be made available. All relays and inputs shall be user-programmable for activation by following event types; Theft, Power Fail Recovery, System Error, Tank Leak, Product Setpoints, Water Setpoints, External Leak sensors, External Contact closure inputs and Line leak. The system shall be supplied with three industrial quality front panel sealed pushbuttons labeled MODE, TANK SELECT, and TEST. Pushbuttons are utilized in conjunction with the display screen to select tank quantities, view, set, acknowledge alarm conditions; set configuration data, initiate system tests, view inventory and other logged data. The system shall provide hardcopy environmental compliance reports via front panel 24 column printer or with optional autowinder take-up spool. The RS-232 serial port shall be provided as standard for two way communications with a PC computer. Microsoft Windows 3.11/95/NT compatible software shall be provided to retrieve and display current tank statuses, remotely read, write and initialize system setup, clock, and configuration data. An RS-485 port shall be provided as standard for connection to Pneumercator "smart" peripherals, such as remote "slave" display and annunciator panels. The system shall be independently third party certified and have the capability to automatically or manually conduct a static volumetric tank tightness test to an accuracy of 0.2 gph for monthly monitoring and 0.1gph for annual precision testing, with minimum test times of two hours and eight hours respectively. System shall be capable of performing both tests with as little as 20% of tank capacity. Console shall be Pneumercator Model Series TMS2000-284.

B. For Multiple Tank Installation - provide and install:

1. Controller: The controller shall be microprocessor-based, and shall be designed and constructed with modular architecture easily permitting either factory or field upgrades and servicing. Configuration and set-up data shall be maintained in non-volatile memory having a minimum fifty (50) year data retention without requiring power of any kind. Replacement or substitution of any controller plug-in card shall not require system re-configuration. Real-time clock and non-critical log data, such as inventory, delivery, alarm, theft, error, and leak reports shall be maintained in battery backed non-volatile memory with a minimum data retention of from (5)-(10) years in the event of a power outage. System shall include digital display for viewing tank information and LED indicators for the alarm conditions.

2. System shall have the capability to continuously monitor up to twelve (12) dual-float magnetostrictive in-tank level probes and up to forty (24) discrete external leak sensors. The system shall provide hardcopy 24 column environmental compliance reports which exit the front panel or are stored internally with optional autowinder take-up spool. The RS-232 serial port shall be standard for communications with a local PC computer. Optional internal modem shall be available for secure telephone link access to the

remotely located PC. Optional Fax/Modem shall be available for secure telephone link access to support class 2 fax transmissions. System shall operate on switch selectable 110/220 VAC(+/- 10%), 50/60 Hz. Maximum power consumption shall be less than 20 watts.

(a) Console: The console shall be housed in a lockable wall mounted NEMA 12 enclosure and optionally available in NEMA 4 or 4x outdoor configurations. A printer option with autowinder shall be available for the outdoor versions. The console shall include microprocessor board, probe/sensor card, power supply, control I/o and communications interfaces. Front panel display shall include audible and visual alarms, user friendly pushbutton controls, and optional impact printer. The display shall be nine digit, seven segment , quasi-alphanumeric super bright LED type, with LED alarm annunciators for five (5) alarm conditions; leak, three (3) tank product setpoints, and one (1) bottom water setpoint per tank. LED alarm lights shall be visible from at least 60 feet and the seven segment display data shall be readable from no less than twenty (20) feet. Displays shall include product gross or net, percent of capacity, 90% ullage, product and water level, product temperature, and product type. Optional user-programmable four (4) Output relay and four (4) contact closure switch input combination plug-in cards (max of 2 cards) shall be supplied and activated for the following event groups; Theft, Power Fail Recovery, System Error, Leak, three (3) Product Setpoints, Water Setpoint, External Leak sensors, External Contact closure and Line leak. The system shall be supplied with three industrial quality front panel sealed pushbuttons labeled MODE, TANK SELECT, and TEST.

Pushbuttons are utilized in conjunction with the display screen to select tank quantities, view, set, acknowledge alarm conditions; set configuration data, initiate system tests, view inventory and other logged data. The system shall provide hardcopy environmental compliance reports via front panel 24 column printer or with optional autowinder take-up spool. The RS-232 serial port shall be provided as standard for two way communications with a PC computer. Microsoft Windows 3.11/95/NT compatible software shall be provided to retrieve and display current tank statuses, remotely read, write and initialize system setup, clock, and configuration data.

(b) An RS-485 port shall be provided as standard for connection to Pneumercator "smart" peripherals, such as remote "slave" display and annunciator panels. The system shall be independently third party certified and have the capability to automatically or manually conduct a static volumetric tank tightness test to an accuracy of 0.2 gph for monthly monitoring and 0.1gph for annual precision testing, with minimum test times of two hours and eight hours respectively. System shall be capable of performing both tests with as little as 20% of tank capacity.

(c) Console shall be Pneumercator Model Series TMS3000-284.

3. Tank Gauging Probe: Probe shall be designed for both AST and UST applications and shall have performance characteristics permitting 0.1 gph or better in-tank leak test with continuous gauging accuracies of +/- 0.0005 inches for product, +/- 0.001 for water and +/- 0.001 degrees F. for (relative) temperature. Probe shall contain an array of at least five (5) temperature sensors along its length for accurate volumetric temperature compensation.

4. Probe to console communication shall employ digital transmission techniques carried over standard, readily available two-conductor, shielded cable, with a maximum cable length restriction of no less than 4000 feet. Probe operating temperature and pressure shall be -40 to +175 degrees F and 150 PSIG respectively.

5. Probes shall be supplied with product float, water float, six (6) foot leader cable with watertight connector, and centering rings for riser mounted applications. Probe shall be UL/CSA approved for use in Class I, Division I, Group C & D hazardous locations.

   (a) Probe shall be Pneumercator Model MP450 for rigid lengths from 2 to 18 feet.
   (b) Probe shall be Pneumercator Model MP451 for rigid lengths from 18 to 25 feet.
   (c) Probe shall be Pneumercator Model MP452 for oil/water separator tanks.
   (d) Probe shall be Pneumercator Model MP460 for flexible lengths from 12 to 85 feet.
   (e) Probe shall be Pneumercator Model MP461 for flexible lengths from 4 to 12 feet.

6. External Passive Leak Sensor: Dry contact switch leak sensors shall be available for liquid detection in interstitial spaces, containment areas, sumps, brine reservoirs, dispenser pans and piping locations.

C. Non-Discriminating Type Liquid Sensors
   1. Alternate sensors shall be 2-wire type consisting of a magnetic, Buna-N float encased within a 1- 1/8 inch diameter, stainless steel outer housing and supplied with twenty-five (25) feet of 2 conductor #18 AWG gage wire. Sensor shall be rated to 50 PSIG at 160F with an accuracy of ½ inch of liquid.
   2. Leak sensor shall be Pneumercator Model LS600-LD-BN.

D. Alternate sensors shall be 2-wire type consisting of a horizontal magnetic float encased within a fabricated PVC outer housing and supplied with twenty-five (25) feet of 2 conductor #18 AWG gage wire. Sensor shall pass through a fiberglass double-wall tank annular space tank opening. Sensor shall provide an accuracy of ½ inch of liquid.
   1. Leak sensor shall be Pneumercator Model LS610.

E. Alternate sensors shall be 3-wire type consisting of a single magnetic float capable of detecting breached inner or outer walls of a double-wall fiberglass tank. The reservoir sensor and its components shall be provided with a non-corroding PVC outer housing, float and guide stem assembly, and sixteen (16) feet of 4 conductor

#18 AWG gage wire. Sensor shall mount in a specified manway on top of each tank and rest on the reservoir floor. The Hydrostatic sensor shall detect changes in the reservoir brine or glycol solution when the level drops below 2 inches or rises above 11 inches of liquid.

1. Leak sensor shall be Pneumercator Model RSU800.

F. External Active Leak Sensors: Two types of active leak sensors shall be offered. Non-discriminating type shall be eletro-optical technology and shall sense only wet or dry conditions. Discriminating type shall employ both eletro-optical and conductivity technologies for detecting and differentiating between hydrocarbon and water. Sensor assemblies shall be provided with a twenty-five (25) foot, 3-conductor, #22 AWG gage wire cable.

Leak sensor shall be (Non-discriminating type) Pneumercator Model ES 825-100.
Leak sensor shall be (Discriminating type) Pneumercator Model ES 825-200.

G. Discrete Sensor Fault Output Feature: Optionally, all Pneumercator leak sensors shall be available with a supervised wiring feature to detect Open or Short-circuited conditions in the sensor field wiring. Active sensor types shall additionally incorporate automatic detection and reporting of sensor internal faults.

1. Leak sensor shall be Pneumercator with "F" Series suffix;
   EG: LS600-LD-BNF
   ES825-200F

H. Overfill prevention shall be provided as follows:

1. Alternate External Remote Audible/ Visual Annunciator: Alarm Console shall consist of two items; a solid state electronic wall mounted NEMA 4X weatherproof enclosure housing Strobe/Siren combination(RA200) and separate A/C power module and wiring junction box. The audible annunciator shall have a minimum rating of 101db at ten (10) feet. The visual annunciator shall be Xenon strobe type with a minimum rating of fifteen (15) candela.

2. Multiple RA200 annunciators shall have the capability of being connected in a daisy chain or parallel configuration. The RA200 shall monitor status of TMS3000 console alarms. The RS-2 Test/Reset remote switch assembly shall also be available in a NEMA 4X enclosure to be used in conjunction with the RA 200 annunciator. The RS-2 shall be supplied in a separate housing, permitting the RA200 annunciator to be mounted with an optimal mounting height for maximum visual and audible range. Acknowledging alarms shall only silence the horn, leaving alarm light lit until condition is corrected. The Test button shall be provided to verify operation of both the audible and visual alarms. System shall operate on switch selectable 110/220VAC(+/- 10%), 50/60 Hz line voltage. Maximum power consumption shall be less than 5 watts.

3. External Remote Annunciator shall be Pneumercator Model RA200.
4. External Remote Test/Reset Switch Assembly shall be Pneumercator Model RS-2.
   Note: Use of either the RA200 or the RS-2 shall require TMS optional accessory
   P/N 900428-(4 relay/4 Non-IS Input I/O Card).

I. Acceptable Products:

Control Console Shall be Pneumercator Co. Model TMS3000.
Tank Level Probe Assembly(s) shall be Pneumercator MP450.
Alternate(Non-discriminating) Leak sensor shall be Pneumercator Model LS600-LD-BN.
Alternate (Non-discriminating) Leak sensor shall be Pneumercator Model LS-610.
Alternate (Non-discriminating) Leak sensor shall be Pneumercator Model RSU800.
Alternate (Discriminating) Leak sensor shall be Pneumercator Model ES 825-100.
Alternate (Non-discriminating) Leak sensor shall be Pneumercator Model ES825-200.
Alternate External Remote Annunciator shall be Pneumercator Model RA 200
Optional:External Remote Test/Acknowledge Switch Assembly shall be Pneumercator Model RS -2
TMS optional accessory P/N 900428 - (4 relay/4 Non-IS Input I/O Card).

2.15 FUEL INFORMATION CABINET SYSTEM TECHNICAL SYSTEMS

A. Major elements of the Fuel Tank Information Cabinet System shall be furnished by a single source vendor to assure design, installation, and service interface, and to provide in-warranty and post-warranty unified responsibility for training of personnel, and supply of replacement parts to Owner and consulting engineer.

B. System vendor shall coordinate product data presented by Fuel Tank Information Cabinet System manufacturer and fuel storage tank manufacturer to provide a comprehensive set of interfaced drawings which will serve as the basis for system evaluation by consulting engineer, and installation by trade contractor designated by Owner.

C. Fuel Tank Information Cabinet System vendor service organization shall employ senor service technicians, having experience in all aspects of trouble shooting, corrective service and preventive maintenance.

D. Furnish and install cylindrical fuel oil storage tank(s) of dimensions as follows. (Each) tank shall have ___ diameter, ____ length, ___ shell thickness. (Each) tank shall be fabricated from best quality "tank steel" sheets, free from liminations, cracks, mill scale, rust, etc. Tank(s) shall be welded throughout. Oil storage tanks shall be delivered to the job as soon as the job conditions permit.

E. The tanks shall be constructed, tested and installed in accordance with NFPA recommendations and shall be furnished with Underwriters' label.

1. The tank manufacturers statement that this tank conforms with 6 NYCRR part 614 New York State Dept. of Environmental Conservation must be permanently displayed.

F. Openings,- Provide all openings, located on top of shell of each tank. Size of opening for each pipe connection shall be the size of pipe connected. Manhole shall have a 3/8-inch thick or heavier steel cover plate with two (2) ½-inch diameter steel lift handles welded to plate and shall be provided with approved heavy ring gasket, etc. Cover plate and gasket shall be secured by (24) 5/8-inch diameter brass bolts and nuts. All couplings for pipe connections shall be continuously welded inside and outside of tank and plates. Manholes shall be 24" diameter.

G. Ladder - From the manhole opening to the bottom of tank, provide a ladder having 3/8 x 2-1/2-inch bar steel sides not less than 16-inches apart and 3/4-inch diameter steer rod rungs spaced on about 12-inch centers. Rungs shall go through the sides and be welded in place. Ladder shall be properly fastened to tank with angles, etc.

H. Coating - The entire exterior of the tank is to be thoroughly cleaned in accordance with specification. SSPC6 for commercial sandblasting. They, by spraying, rooling or brushing, a steel tank institute approved coating is to be applied to the entire exterior of the tank of a minimum dry film thickness of 10 mils on the shell and 15 mils on the heads.

I. Affidavit - An affidavit stating that the thickness of steel, inside and outside welding and coating of tanks have fully complied with the specified requirements, shall be obtained from the manufacturer and delivered to the Owner.

J. Identification - Each tank shall be provided with an approved type and size number plate indicating the tank number and attached to tank at a conveniently visible location in the access space.

K. Test - Each tank shall be pressure tested at seven pounds per square inch pressure or greater if required by local code. Tests shall be made in the presence of authorized representatives of the Owner.

L. Furnish and install where directed two (2) charts for determining the amount of oil in tank when measured with a rod. Furnish one (1) rod.

PART 3 - EXECUTION

3.1 CONCRETE BASES

A. Install concrete bases for fuel oil transfer pumps. Refer to Division 3 Section "Cast-in-Place Concrete."

3.2 SERVICE ENTRANCE PIPING

A. Extend fuel oil piping and connect to oil distribution system supply piping in the location and of the size indicated for supply entrance to building.

3.3 PIPING APPLICATIONS

A. General: Flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating may be used in applications below, except where otherwise indicated.

3.4 VALVE APPLICATIONS

A. Drawings and specifications indicate valve types used. Where specific types are not indicated, the following requirements apply:

1. Shutoff Duty: Use gate, ball, or butterfly valves.

2. Throttling Duty: Use globe or butterfly valves.

3.5 PIPING INSTALLATIONS

A. Refer to other sections in Division 15 for additional piping installation requirements.

B. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

C. Install strainers on supply side of each control valve, pressure-regulating valve, oil burner connection, and elsewhere as indicated. Install 3/4-inch NPS (DN20) pipe nipple and ball valve in blow-down connection of strainers 2-inch NPS (DN50) and larger. Use same size nipple and valve as blow-off connection of strainer.

D. Install dielectric fittings (unions and flanges) with ferrous and brass or bronze end connections, separated by insulating material, where piping of dissimilar metals is joined.

E. Anchor piping to ensure proper direction of piping expansion and contraction. Install expansion joints, expansion loops, and pipe guides as indicated.

F. Prepare and paint outside of containment conduits with coal-tar epoxy-polyamide paint according to SSPC-Paint 16.

3.6 JOINT CONSTRUCTION

A. Refer to other sections in Division 15 for piping joint construction.

3.7 VALVE INSTALLATION

A. Install shutoff, drain, and check valves as specified and as required.

B. Provide approved anti-siphon valves at all high points of the suction line.

C. Install valves in accessible locations, protected from damage. Tag valves with metal tag indicating piping supplied. Attach tag to valve with metal chain.

D. Install valves at each branch connection to supply mains and elsewhere.

E. Install drain valves at low points in mains, risers, branch lines, and elsewhere as required for system drainage.

3.8 HANGER AND SUPPORT INSTALLATION

A. Refer to other sections in Division 15 for pipe hanger and support devices.

B. Support vertical steel pipe at each floor and at spacing not greater than 15 feet (4.5 m).

3.9 CONNECTIONS

A. Install fuel oil piping next to equipment using fuel oil to allow service and maintenance.

B. Connect fuel oil piping to equipment using fuel oil with shutoff valves and unions. Install valves upstream from equipment. Install union or flanged connection downstream from valves. Include flexible connectors where indicated.

C. Sediment Traps: Install tee fitting with capped nipple in bottom forming drip, as close as practical to inlet of equipment using fuel oil. Fabricate drip leg with a minimum length of 3 pipe diameters.

D. Ground equipment.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

E. Electrical Connections: Wiring is specified in Division 16 Sections.

3.10 FIELD QUALITY CONTROL

A. Inspect and test fuel oil piping according to NFPA 30 "Testing" Paragraph and NFPA 31 "Tests of Piping" Paragraph.

B. Oil suction line piping shall be tested at 25 inch vacuum prior to backfilling. Piping shall be tested at a minimum of 1½ times the design operating pressure (minimum of 225 psig) prior to backfilling. Submit witnessed affidavit to engineer.

C. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.

D. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Report test results promptly and in writing to Architect.

3.11 DEMONSTRATION

A. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.

B. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Contract Closeout."

C. Review data in the operation and maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

D. Schedule training with Owner with at least 7 days' advance notice.

3.12 START-UP

A. Perform these steps before activating system:

1. Open valves to fully open position and close bypass valves.

2. Remove and clean strainer screens.

3. Fully prime system.

4. Energize pump and check for proper direction of rotation.

5. Check operating controls of fuel burner units.

6. Check operation at automatic bypass valves.

7. Check prime. Reprime, as required.

END OF SECTION 15591

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15681 - AIR COOLED REFRIGERATION MACHINE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The requirements of the General Conditions, Supplementary Conditions, and the following specification sections apply to all Work herein:
1. Section 15010 - Basic Mechanical Requirements.
2. Section 15050 - Basic Mechanical Materials and Methods
3. Section 15170 - Electric Motors and Controllers.
4. Section 15240 - Mechanical Sound and Vibration Control
5. Section 15250 - Mechanical Insulation
6. Section 15500 - Heating, Ventilating & Air Conditioning
7. Section 15540 - Pumps.
8. Section 15545 - Water Treatment Systems.
9. Section 15990 - Testing, Balancing, and Adjusting.

1.2 SUMMARY

A. Furnish and install new packaged, air-cooled water chilling units as specified hereinafter and as indicated on the Drawings.

1.3 REFERENCE STANDARDS

A. All air cooled water chilling units and accessories shall be designed, manufactured, and tested in accordance with the latest applicable industry standards including the following:
1. ANSI B9.1 safety code.
2. ANSI/ARI 590 code for testing and rating of reciprocating water chillers.
3. ANSI/UL 465 code for construction of reciprocating water chillers.
4. ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of reciprocating water chillers.
5. ANSI/ASHRAE 15 code for construction and operation of reciprocating water chillers.
6. ANSI/ASHRAE 90A - Energy Conservation in New Building Design.
7. ANSI/NEMA MG 1 - Motors and Generators
8. ASME.

1.4 QUALITY ASSURANCE

A. After completion of installation, but prior to Substantial completion, Contractor shall certify in writing that products and materials installed, and processes used, do not contain asbestos or polychlorinated biphenyl's (PCB), using the format in Article 3 of the General Conditions. In the event no product or material is available that does not contain asbestos, PCB or hazardous materials as determined by the Owner, a "Materials Safety Data Sheet" (MSDS) equivalent to OSHA Form 20 shall be submitted for that proposed product or material prior to installation.

B. In the event that materials, products, and/or processes being proposed for this Project contain, or may emit, any volatile organic compounds (VOC), formaldehyde formulations, or hazardous out-gassing, as determined by the manufacturer, a “Materials Safety Data sheet”, as described above, shall be submitted as part of the shop drawing process for review by the Engineer and/or Owner.

C. All equipment and material to be furnished and installed on this Project shall be UL or ETL listed, in accordance with the requirements of the Authority having jurisdiction, and suitable for its intended use on this Project.

1.5 SUBMITTALS

A. The following submittal data shall be furnished according to the Conditions of the Construction Contract, Division 1 Specifications, and Section 15010 and shall include but not be limited to:

1. Air Cooled Water Chilling Unit*, complete with physical dimensions, materials, capacity data, water pressure drops, foundation requirements, vibration isolation, controls, connection details, motor controller, oil pump motor controller, electrical characteristics, acoustical data, etc.

B. All items or equipment listed above with asterisks (*) shall be certified by the manufacturer using Manufacturer Certification "MCA" as set forth in Section 15010. See Section 15010 for certification requirements.

1.6 WARRANTY

A. Comply with the requirements of the General Conditions and Section 15010.

PART 2 - PRODUCTS

2.1 UNAUTHORIZED MATERIALS

A. Materials and products required for the work of this section shall not contain asbestos, polychlorinated biphenyl’s (PCB) or other hazardous materials identified by the Owner.

2.2 ACCEPTABLE MANUFACTURERS

A. If it complies with these Specifications, air cooled water chilling units manufactured by one of the following manufacturers will be acceptable:

1. Carrier.
2. McQuay.
3. Trane.
4. York.

2.3 GENERAL

A. Furnish and install complete, factory assembled and tested, packaged air-cooled reciprocating, scroll, or rotary type water chilling unit of the size and capacities listed in the “Schedule of Capacities” on the Contract Documents.

B. Unit shall consist of a reciprocating compressor or multiples thereof, evaporator, air cooled condenser, refrigeration accessories, control panel, and factory wiring and interconnecting refrigerant piping contained within the unit enclosure. Unit shall contain a complete operating charge of Refrigerant R-134a (or approved HFC) and oil.

C. Unit shall contain factory-installed diagnostic system, capable of indicating status of all safeties and energizing remote alarm.

D. Unit construction shall comply with the reference standards.

E. Unit shall be capable of starting with up to 95ºF entering water temperature to the evaporator.

F. Unit shall control the scheduled leaving chilled water temperature.

G. The evaporator shall be connected to the mechanical system chilled water piping system with connection type used by Contractor.

2.4 COMPRESSORS

A. Reciprocating compressors shall be serviceable semi-hermetic type with heat treated forged steel or ductile iron crankshafts, aluminum alloy connecting rods, automotive type pistons, rings to prevent gas leakage, and sealing surface immersed in oil. The main bearings shall be insert type, steel-backed babbit. Thrust bearing shall be bronze.

B. Scroll type compressors shall be direct drive suction gas-cooled, with hermetic motor.

C. Rotary type compressors shall be direct drive suction gas-cooled.

D. Statically and dynamically balance rotating parts and factory mount on spring or rubber-in-shear vibration isolators. Refer to Section 15245 titled "Vibration Isolation" for additional requirements.

E. Lubrication shall be provided by reversible, positive displacement, oil pump with oil charging valve; oil level sight glass; and fine mesh stainless steel oil strainer with magnetic plug arranged to provide adequate lubrication during starting, stopping, and normal operation. Provide operating oil charge.

F. Provide compressor with automatic capacity reduction equipment consisting of electrically-actuated suction valve cutoff cylinder unloaders. Provide for unloaded compressor start.

G. Provide constant speed 3600 rpm compressor motor, suction gas cooled with solid-state sensor and electronic winding overheating protection in each phase, designed for across-the-line. Terminal boxes shall be rain-tight. Refer to Section 15170 titled "Electric Motors and Controllers" for additional requirements. Furnish with motor starter.

H. Provide insertion type crankcase heater for each compressor sized to evaporate refrigerant returning to crankcase during shutdown. Energize heater continuously when compressor is not operating.

2.5 EVAPORATOR

A. Evaporator shall be dual-circuited tube-in-shell, direct expansion type with refrigerant in tubes and chilled liquid flowing through the baffled shell. Provide seamless or welded steel shell construction with removable cast iron or fabricated steel heads. Tubes shall be seamless copper or red brass with integral fins, rolled or silver brazed into tube sheets. Water baffles shall be galvanized steel or polypropylene. Provide multiple refrigerant circuits on multiple compressor units.

B. Design, test, and stamp refrigerant side for 225 psig working pressure and water side for 150 psig working pressure, in accordance with ANSI/ ASME Unfired Pressure Vessel Code, Section VIII, Division (1).

C. Provide vent and water drain connections and thermometer wells for temperature controller and low temperature cutout.

2.6 CONDENSER

A. Condenser shall be an integral air-cooled type with configurated copper aluminum plate fins mechanically bonded to seamless copper tubing. Provide integral sub-cooling circuits with liquid accumulators. Condenser shall be factory cleaned, dehydrated, sealed and leak-tested with air, underwater, at 425 psig air pressure.

B. Condenser fins shall be coated with a black epoxy designed for corrosion resistance in chloride environments.

C. Condenser fans shall be aluminum, airfoil type, direct driven by independent motors, arranged for vertical discharge, and provided with PVC coated heavy gauge steel wire safety guards on fan discharge. All blades shall be statically and dynamically balanced. Fans shall be furnished with permanently lubricated ball bearings.

D. Contractor shall furnish and install condenser fan discharge duct extension as recommended by the water chilling unit manufacturer to meet the capacity guarantee requirement specified. Water chilling unit manufacturer shall notify the contractor of this requirement at time of bid.

E. Condenser fan motors shall totally enclosed air-over induction type with built-in three-phase current and thermal overload protection. The unit shall have a factory-installed stepdown transformer if the fan motor voltage is different from the unit power input voltage. Refer to Section 15170 titled "Electric Motors and Controllers" for additional requirements.

2.7 INSULATION

A. All cold surfaces of the water chilling unit (including, but not limited to, the evaporator and evaporator heads, the suction piping between the evaporator and compressors, the cold gas connection to gas-cooled motors, and the chiller water pipe nozzles inside the unit) shall be insulated with 3/4" thick flexible elastomeric, closed cell sheet insulation (ASTM C534) or Engineer accepted equivalent. Insulation shall have a maximum thermal conductivity (K-factor) of 0.28 Btu _In/Hr _SF _ºF at 75ºF mean temperature when tested by ASTM C177 and a water vapor permeability of 0.17 perm-inch or less when tested by ASTM C355 Water Method.

B. In addition, the evaporator shall have a thermostatically controlled heat tracing tape wrapped around the shell under the factory-applied insulation. The manufacturer shall certify on the Shop Drawing that the evaporator is protected from freezing with -20ºF ambient temperature with power and estimate the duration of freeze protection at -20ºF when there is a loss of power.

C. The insulation shall be finished with insulation manufacturer's recommended weather protective coating; color to be the water chilling unit manufacturer's standard.

D. The Contractor shall field insulate any areas that show evidence of condensation during operation after installation. Field insulation and finish shall be the same as the factory insulation.

2.8 UNIT CASING

A. Unit shall be constructed of heavy gauge galvanized steel frame and panel casing, zinc phosphatized, and coated with a weather-resistant baked-on enamel finish. Unit structure and casing shall be painted with weather resistant enamel which meets the ASTM B117, 500 hour, 5% salt spray requirement. Color shall be manufacturer's standard.

B. Mount starters and disconnects in weatherproof panel provided with full opening access doors. Provide mechanical interlock to disconnect power when door is open. Provide adequate wind bracing to hold doors rigidly in place when opened.

2.9 CHILLER CONTROLS

A. Unit shall have a control box which contains: high and low pressure cut-out switched for each refrigerant circuit, manual reset low water temperature cut-out switch, power terminal blocks, and circuit breakers for compressor motor overload protection.

B. Microprocessor control panel shall provide control functions for start-up and shut down, leaving water temperature control, compressor and electronic expansion valve modulation, fan sequencing, anti-recycle logic, compressor lead/lag load limiting, and multiple chiller lag/log. Provide contacts for alarm interface to BAS.

C. Control panel shall provide protective functions including loss of chilled water flow, evaporator freezing, loss of refrigerant, low refrigerant pressure, high refrigerant pressure, reverse rotation, over current, phase loss, and loss of oil flow.

D. Compressor shall be limited to no more than six (6) cycles per hour.

E. A menu driven digital control panel shall display operating points including chilled water set point, current limiting set point, leaving water temperature, evaporator and condenser refrigerant pressures and temperatures, diagnostic checks and alarms. Digital control panel shall be mounted on the unit casing to be read and advanced without opening any control panel doors.

2.10 STARTERS

A. Provide Star (Wye) Delta starters housed in a weather-tight enclosure with removable cover plates and to comply with Division 16.

2.11 PROTECTIVE COATING

A. Chiller manufcturer shall include in his price, protective coating either from the factory or a company specializing in coating this type equipment per the following specifications. Coating application by Diversified Mechanical Services of Highlands, Texas will be acceptable if it meets these specification.

2.12 REFRIGERANT CIRCUIT

A. The unit shall have a minimum of two (2) completely independent direct expansion refrigerant circuits, factory supplied and piped, with a minimum of two (2) compressors per circuit. All unit piping shall be copper with brazed joints.

B. Provide for each refrigerant circuit:

1. Liquid line solenoid shutoff valve.
2. Filter dryer (replaceable core type).
3. Liquid line sight glass and moisture indicator.
4. Stepping motor actuated electronic expansion valve sized for maximum operating pressure.
5. Charging valve.
6. Insulated suction line and liquid line between expansion valve and evaporator.
7. Discharge line check valve.
8. Compressor discharge service valve.
9. Condenser pressure relief valve.
10. Hot gas muffler (except for units with scroll compressors).

C. Electronic expansion valves shall have maximum operating pressure characteristics to limit inlet suction pressure.

D. Units shall include suction and discharge pressure gauges with manual shutoff valves, or pressure transducers to display pressures on digital control panel display.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Air cooled water chilling units and accessories shall be installed in accordance with the latest industry standards, per the manufacturer’s recommendations, and as indicated on the Drawings.

B. If the air cooled water chilling unit factory vacuum or pressure is lost because of leaks, the Contractor shall conduct a standing pressure test on the refrigerant circuit for a period of 12 hours using nitrogen. Do not exceed test pressure recommended by the manufacturer. All detected leaks shall be repaired and the test repeated until system is leak-proof. The Contractor then shall conduct a standing vacuum test on the vessel equal to 1 mm Hg absolute using a vacuum pump, for a 24-hour period. All detected leaks shall be repaired and the test repeated until system is leak-proof. Refrigerant of the highest quality shall be charged, through filter-dryers, to the "at rest" level marked on the refrigerant sight gauge glass. Machines shipped pre-charged need not comply with this requirement unless the factory pre-charge or holding charge is lost during shipment or prior to startup, in which case the Contractor shall pressure test, vacuum test, repair leaks and charge as specified herein in this paragraph. Oil will be added to the machine and all startup and check out procedures shall be performed in such a manner as not to introduce moisture into the machine.

C. The Contractor shall furnish and install all necessary relief valves, flexible connectors, auxiliary water piping for oil coolers, and all piping, valves, fittings, and all necessary connections for a complete and workable system in accordance with the air cooled water chilling unit manufacturer's recommendations.

D. The Contractor shall install each unit on isolation as specified in Section 15245 titled "Vibration Isolation".

E. The Contractor shall level each machine in accordance with the manufacturer's recommendations. The vibration isolators shall not be used to level the machine.

3.2 FACTORY TESTING

A. All air cooled water chilling units shall be tested in accordance with the latest applicable ARI industry standards and as specified herein. For identical water chilling units, only one (1) unit may be tested, however the compressors on all machines shall be 100% run-tested to ensure proper operation of all compressor systems.

3.3 FACTORY TESTING

A. Refer to Section 15990 for additional testing requirements for air cooled water chilling units and accessories.

END OF SECTION 15681

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SECTION 15784 - CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Central Station Air Handling Units.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this section.

B. Section 15010 - Basic Mechanical Requirements.

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is part of each Division 15000 Section.

E. Division 16000 - Electrical .

1.3 REFERENCES

A. AMCA 99 - Standard Handbook.

B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

D. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

E. AMCA 500 - Test Methods for Louver, Dampers, and Shutters.

F. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

G. ANSI/UL 900 - Test Performance of Air Filter Units.

H. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.

I. ARI 430 - Standard for Central-Station Air-Handling Units.

J. ARI 435 - Standard for Application of Central-Station Air Handling Units.

K. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

L. SMACNA - Duct Construction Standards.

1.4 SUBMITTALS

A. Submit the following according to the Conditions of the Contract and as specified in Division 1 Section “Submittals” and Division 15000.

B. Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances for maintenance, coil removals, etc., construction details, and field connection details.

C. Product data shall indicate dimensions, weights, capacities, ratings, fan performance, sound data, motor electrical characteristics, and gauges and finishes of materials.

D. Provide fan curves with specified operating point clearly plotted.

E. Submit product data of filter media, filter performance data, filter assembly, and filter frames.

F. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.

G. Submit manufacturer's installation instructions.

1.5 QUALITY ASSURANCE

A. Fan Performance Ratings: Conform to AMCA 210.

B. Sound Ratings: ARI 410.

C. Fabrication and Performances: Conform to ARI 430.

D. Filter Media: ANSI/UL 900 listed, Class I or Class II, approved by local authorities.

E. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410.

F. Direct expansion coils shall be designated and tested in accordance with ANSI/ASHRAE 15 Safety Code for Mechanical Refrigeration.

G. Insulation and insulation adhesive shall comply with NFPA 90A requirements for flame spread and smoke generation.

H. Air Handling Units: Product of manufacturer regularly engaged in production of components who issues complete catalog data on total product.

I. Certify air volume, static pressure, fan speed, brake horsepower and selection procedures in accordance with ARI 430. If air handling units are not certified in accordance with ARI 430, contractor shall be responsible for expenses associated with testing of units after installation to very performance of unit. Any costs incurred to adjust unit components to meet scheduled capacities shall be the sole responsibility of the contractor.

J. Unit Leakage

1. Each air handling unit shall be tested to verify casing leakage and certified test results shall be submitted to the engineer for review.

2. Casing leakage shall be less than 1% of maximum design airflow at 1.25 times the design total static pressure (minimum of 5"). The positive pressure sections shall be tested under positive pressure and the negative pressure sections shall be tested under negative pressure.

K. Unit shall be manufactured in a facility registered to ISO 9002 manufacturing quality standard.

L. Unit shall be constructed in accordance with ETL and CSA standards and shall carry the ETL and CSA labels.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Division 1. Leave factory shipping covers in place until installation.

B. Store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

C. Comply with manufacturer's installation instructions for rigging, unloading and transporting units.

1.7 OPERATION AND MAINTENANCE DATA

A. Include start-up instructions, operations and maintenance data.

B. Start-up: Manufacturer shall furnish factory representative to supervise erection, testing and starting of the machines, including owner instruction.

C. Submit operation and maintenance data under provisions of Division 1. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing and design of absorption products with minimum 10 years experience.

B. Equipment Supplier: Company must submit local organizational chart detailing sales, service, and parts capabilities

C. Local service should be located within 100 miles of job site.

1.9 WARRANTY

A. Manufacturer shall provide a full parts and labor warranty for a period of two (2) years from date of initial start-up and acceptance by the owner. Manufacturer must maintain a local full time parts and service company capable of responding to service needs within 24 hours.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.11 EXTRA STOCK

A. Provide one set of filters as specified under another Section.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier.

B. Trane.

C. York.

D. Air Enterprises.

E. Mammoth

F. Buffalo Forge

G. Governair.

2.2 GENERAL DESCRIPTION

A. Units shall be of heavy duty commercial grade construction, suitable for the scheduled duty requirements. Where required for the indicated system static pressures, or if specifically so noted on the drawings, units shall be of high pressure design.

B. Fabricate draw-thru type air handling units suitable for the scheduled capacities.

C. Fabricate units with a supply fan segment plus accessories, including cooling coil segment, heating coil segment, integral face and bypass coil segment, preheat coil segment, filter segment, mixing box segment face and bypass damper segment, access segment.

D. Factory fabricate and test air handling units of sizes, capacities, and configuration as indicated and specified.

E. Base performance on sea level conditions.

F. All internal components specified in the air handling unit schedule shall be factory furnished and installed. Unit(s) shall be completely factory assembled.

G. Units shall ship in one (1) piece where possible. Shipping splits can be provided as required for installation. Lifting lugs will be supplied on each side of the split to facilitate rigging and joining of segments.

H. Units with shipping splits shall be provided with "male" and "female" connection pieces for easy field assembly. Units requiring field installed gasketing must be assembled under supervision by factory trained and employed personnel from the air unit manufacturer.

I. The fan discharge shall be connected to the fan cabinet using a flexible connection to insure vibration-free operation. The isolator support rail shall be structurally supported from the unit base.

2.3 CASING

A. Casing - Panels constructed of medium hot rolled steel or zinc coated steel. Welded framework construction. The frame shall be constructed to permit complete removal of the wall and roof panels without affecting the structural integrity of the unit. All panels are removable. The entire unit shall be provided with a full-length, continuous, base rail channel.

B. All segments shall be double wall, formed and reinforced to provide a rigid assembly. The exterior casing shall be constructed of a minimum G90 -u galvanized steel. The interior lining shall be a perforated lining of a minimum of 20 gage.

C. Access - One insulated access section, minimum of 18" deep in the direction of air flow, full height and width of unit, on the inlet side of each coil as well as in the fan, filter and humidifier sections.. Access sections shall be provided with a full size hinged and gasketed access door with quick opening “Ventlok” handles. Access section upstream of the first coil in the airstream need not be insulated.

D. Insulation: Entire unit interior to be insulated with moisture proof, fire resistant, two inch (2") thick 1½ lb. density neoprene coated glass fiber blanket, cemented to internal surfaces, conforming with NFPA Standards for duct lining, plus an **perforated lining or a minimum of 20 gage** of galvanized steel to protect the acoustic liner from damage.

E. Unit Finish: The exterior of the unit shall be completely cleaned prior to application of finished coats. A prime coat of epoxy chromate shall be applied to a minimum thickness 1.5 mils. A finish coat of beige acrylic polyurethane shall then be applied to a minimum thickness of 2.5 mils.

F. When tested in accordance with ASTM B-117 the finished unit shall withstand 125 hour salt spray solution (5%) without any sign of red rust.

2.4 FANS (PLUG FAN)

A. Fan to be selected at or near efficiency peak. (Submit fan curves.) Unit shall be of manufacture as noted on drawings, or approved.

B. Fan Section

1. General - Fan performance ratings shall be certified in accordance with ARI Standard 430

2. Housing - Streamlined and designed for low air velocities.

3. Provide supply fan sections with AF single width, single inlet centrifugal plug fans designed and suitable for class of service indicated on unit schedule. Fan shaft to be properly sized and protectively coated width lubricating oil. Fan shafts shall be solid and properly designed so that fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fans shall be statically and dynamically tested as an assembly at the required RPM to meet design specifications. key fan wheels to fan shaft to prevent slipping. High pressure air handling units shall only be furnished with Class III air foil fan wheels.

4. Fans shall be statically and dynamically balanced at the factory prior to shipment. After the pre-balanced fan is installed in the air handler, the entire fan section shall be run-balanced at the specified speed to insure smooth and trouble-free operation.

   Fans with variable frequency drives shall be balanced for inverter duty operation. The fan will be balanced over the entire range of fan operation (30% to 100% of RPM). Filter-in measurements shall not exceed 5 mils in the horizontal and vertical planes. Filter-out measurements shall not exceed 7.5 mils in the horizontal, vertical and axial planes.

   Shaft - Shall be solid or tubular steel and shall not pass through the first critical speed as unit comes up to rated rpm. Fan wheels to be secured with slotted keyways on solid shafts and with taper lock hubs on tubular steel shafts.

5. Bearings - Self-aligning, grease lubricated, ball type. Internal bearings, where used, shall be provided with extended fittings mounted externally at drive side of unit. Minimum 400,000 hours average life, as defined by AFBMA.

6. Drive - Adjustable, minimum of two grooves furnished on all motor sizes. Drive sized for 1.5 x motor H.P. Belt guard to meet OSHA requirements and to have access opening for RPM readings. Provide belt guard (whether motor is inside or outside unit).

7. Fan and fan motor shall be internally mounted and isolated on a full width isolator support bases as specified under another Section. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A. If no isolators is provided, then the entire unit shall be externally isolated from the supply duct work and piping by contractor in order to avoid transmission of noise and vibration through the ductwork.

8. Fan sections shall have full height, double wall, hinged, removable access doors on drive side for inspection and maintenance of internal components.

   (a) To facilitate inspection of internal components, provide sealed glass and wire view windows on access doors

2.5 ELECTRICAL CHARACTERISTICS AND COMPONENTS

A. Electric Motors: For electric motors, see detailed specifications elsewhere. Scheduled brake horsepower shall not be exceeded. All motors shall be high efficiency.

B. The motor shall be mounted on the same isolation base as the fan. The motor shall be on a slide base to permit adjustment of belt tension.

C. Fan unloading for variable-air-volume control shall be accomplished through a field mounted variable frequency drive, as specified under another Section.

After final assembly, the fan and motor assembly shall be factory balanced for 10 - 100% of design speed of the air handling unit. Units that are balanced for a specific point of operation shall be field balanced for the entire RPM range.

After the air handling unit is installed, the VFD shall be field commissioned by a factory trained and employed service technician.

D. A marine-type, vapor proof service light shall be provided in the fan segment and additional segments.

A single 115 volt convenience outlet shall be provided at the light switch.

2.6 COILS

A. All cooling and/or heating coils shall be furnished to meet the performance requirements set forth in the schedule and as specified under another section of this work. All coils shall have performance certified in accordance with ARI Standard 410.

B. All coils shall be factory installed on tracks for easy removal from the air handling unit. Units that require dis-assembly of the unit for coil removal are not acceptable. Install coils such that headers and return bends are enclosed by unit casings.

C. Coil casing to be constructed of 16 gage stainless steel. Intermediate casing supports shall be supplied for finned lengths that exceed 60".

2.7 FILTERS

A. All filters shall be furnished to meet the performance requirements set forth in the schedule and as specified under another section of this work. All coils shall have performance certified in accordance with ASHRAE and shall be UL Rated.

The filter frames shall be constructed of galvanized steel and be built as an integral part of the unit. All filter segments shall be serviceable with access doors.

B. A magnahelic, differential pressure gage shall be factory installed and flush mounted on drive side to measure the pressure drop across the filters.

2.8 APPURTENANCES

A. The Mixing Box Segment shall consist of multi-leaf acting blades, with inter-connecting return air and outside air dampers. The dampers shall be located as indicated on the drawings.

B. No water carry-over from cooling coils into air stream accepted. Eliminators shall be provided where required by unit manufacturer. Pressure drop across eliminator shall be maximum 0.25" W.G. at 500 FPM, coil face velocity.

C. The Access Segment(s) shall be provided for placement anywhere in the unit to gain access to a particular area. The access segment shall be available with a depth of 18"..

D. The Discharge Plenum shall be provided as the last segment in direction of airflow, as indicated on the drawings.

2.9 DRAIN PAN

A. All cooling coils, humidifier and fan section to be provided with drain pan. Drain pan shall be constructed of one-piece welded outer casing double floor construction, with drain connections on both sides. Drain pan shall be sloped to assure positive drainage.

B. Material - Medium hot rolled steel or zinc coated steel outer casing, mastic coated steel inner pan, conforming to ASTM A 525, G 90 (ASTM A 525M, Z 275).

C. Pan shall be installed under coil and extending a minimum of 18" past end of coil. Pan to be drained with piping leading to floor drain.

D. Where coils are stacked two or more high within the unit provide mastic coated steel intermediate drain troughs, piped to the main drain pan, between each pair of coils.

E. Insulation - ½" closed cell plastic, coated with an asphaltum binder cemented to inside surface with waterproof adhesive or fiberglass, between inner pan and outer casing

Pan top surface coating: Elastomeric compound.

2.10 HUMIDIFIERS

A. Humidifier: Factory installed steam grid type humidifiers of the steam injection type utilizing an enclosed manifold to discharge clean dry steam into the air stream. Enclosure of all copper construction with slotted top opening. Perforated copper distribution tube. Condensed steam to drip directly to and be drained from the bottom of the enclosure.

B. Humidifiers sized for capacities indicated in the schedule shall be Johnson Service Company Model II-201 or equivalent by Armstrong Machine Works, properly positioned in air handling units at unit manufacturer's factory.

2.11 DAMPERS

A. All Dampers shall be furnished to meet the performance requirements set forth in the schedule and as specified under another section of this work. All Dampers shall be of low leak design.

B. Zone Dampers: (Multizone) where required. Shafts to turn in heat and corrosion resistant bearings on bushings. Provide stationary partitions between each blade and gasketing material around the entire periphery of all bladed, for positive seal. Provide means for proper positioning of blades.

2.12 PERFORMANCE

A. Performance: Noted on schedules, to be rated as a completely assembled unit.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in conformance with ARI 435.

C. Assemble high pressure units by bolting segments together. Isolate fan segment with flexible duct connections.

D. Provide for connection to electrical service.

E. Align unit on concrete foundations. Level and grout in place.

F. Install units on vibration isolation.

G. Provide connections to chilled water piping.

H. Provide hot water connections to hot water piping.

END OF SECTION 15784

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15681 - AIR COILS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This Section includes the following:

1. Cooling Coils (Chilled Water).

2. Heating coil (Hot water).

3. Electric Duct Heating Coils.

4. Pre-heat coils (Vertical Tube Integral Face and By-Pass).

5. Refrigerant Coils.

6. Heat Recovery Coils.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section 15010 - Basic Mechanical Requirements.

C. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

D. This section is a part of each Division 15000 Section.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product data including rated capacities of selected models, pressure drop, weights (shipping, installed, and operating), installation instructions, and startup instructions.

C. Shop drawings detailing fabrication and installation of air coils, including plans, elevations, sections, details of components, and attachments to other units of Work. Detail connections to piping and electrical wiring. Indicate dimensions, weight loadings, weight distribution, and clearances required.

D. Wiring diagrams detailing electrical connections to duct heaters for wiring for power, signal, and control systems, differentiating clearly between manufacturer-installed wiring and field-installed wiring.

E. Qualification data as specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

F. Maintenance data for air coils to include in the operation and maintenance manual specified in Division 1.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Firm experienced in manufacturing air coils and duct heaters similar to those indicated for this Project and that have a record of successful in-service performance.

B. Comply with NFPA 70 "National Electrical Code" for components and installation.

C. Listing and Labeling: Provide products specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.

D. All coils shall be ARI Performance Certified.

E. Single-Source Responsibility: Obtain air coil components from one source and by a single manufacturer.

1.5 COORDINATION

A. Coordinate layout and installation of air coils with duct, insulation, and with other installations. Revise locations and elevations from those indicated as required to suit field conditions, and as approved by the Engineer.

1.6 DI-ELECTRIC FITTINGS

A. Provide dielectric fittings to isolate joined dissimilar materials to prevent galvanic action and stop corrosion. Fittings shall be of the non-reducing type, which shall be suitable for the system fluid, pressure and temperature and shall not restrict the flow. See section 15050 for additional requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. Heating Coils (Hot Water):

(a) Aerofin Corporation

(b) Heatcraft

(c) Carrier Corporation.

(d) Marlo

(e) Dunham-Bush, Inc.

2. Cooling Coils (Chilled Water):

(a) Aerofin Corporation

(b) Heatcraft

(c) Carrier Corporation.

(d) Marlo

(e) Dunham-Bush, Inc.

3. Electric Duct Heating Coils

(a) Indeeco

(b) Brasch Manufacturing Co.

(c) Chromalox

4. Pre-heat Coils (Vertical Tube Integral Face & Bypass) Coils:

(a) Wing Corporation.

5. Heat Recovery Coils

(a) Aerofin Corporation.

(b) Heatcraft

(c) Marlo
(d) Carrier Corporation.

(e) Armstrong - Hunt

(f) Dunham-Bush, Inc.

6. Refrigerant Coils:

(a) Aerofin Corporation.

(b) Dunham-Bush, Inc.

(c) York

(d) Carrier Corporation

2.2 COOLING COILS (chilled water)

A. General: All coil ratings shall be certified by A.R.I. Coils to have continuous water circuits from the inlet header to the outlet header. All joints in the water circuit are to be brazed. Coils are to be of the self-venting type. A vent connection is to be provided in the supply header and a drain connection in the return header. Each drain and vent outlet to be fitted with a hose-end valve, packless type, and a pipe cap. Each coil to bear the seal indicating manufacturer's compliance with ARI Standard 410

B. Headers: constructed of a close-grained gray cast-iron, steel pipe, or heavy wall copper. Provide cleanable type headers.

C. Tubes: seamless deoxidized copper, 5/8" O.D. minimum and .020" minimum wall thickness. With the specified circuiting, water velocity not to exceed 6 feet per second.

D. Fittings: return bends to be fabricated from 5/8" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to .020" or greater.

E. Joints: tube joint between fittings and tubes; and tubes and header to be brazed.

F. Fins: plate type or helically wound on the tubes. Aluminum fins standard. Copper fins mandatory on sprayed coils. The plate type aluminum fins shall be continuous across the entire width and depth of the coil section and the tubes shall be mechanically expanded into the fins.

G. Casing: zinc coated, rust resistant steel or aluminum. Top and bottom casing flanges are to be formed into a box shape for strength and durability, with a flat surface for coil stacking. Tube support sheets to be aluminum or zinc coated rust-resistant steel.

H. Testing: before shipment, coils to be subjected to a 250 psig air test under water or greater as required.

I. Operating Limits: coils to be designed, tested and guaranteed for operation with water pressure and temperature required by specific job application. Conform pressures designated for valves and fittings.

J. Drain Pan: All cooling coils to have 316 stainless steel drain pan. Pan to be installed under coil and extending a minimum of 18" past end of coil. Pan to be drained with piping leading to floor drain.

Coils installed in more than one section high to have intermediate pans. Each pan to be individually drained with piping to outlet pipe leading to floor drain.

Insulation - ½" closed cell plastic, coated with an asphaltum binder cemented to inside surface with waterproof adhesive.

Multiple coils in air handling units to be provided with built in troughs.

K. Coil Performance: all data pertaining to coil performance are shown elsewhere. All coils shall be piped counterflow.

L. Moisture Eliminators: No water carry-over from cooling coils into air stream accepted. Eliminators shall be provided where required by unit manufacturer. Pressure drop across eliminator shall be maximum 0.25" W.G. at 500 FPM, coil face velocity.

M. Coil Limitations:

Cooling coils	Not more than 8 fins per inch (recirculating). Not more than 10-1/2 fins per inch (100% outside air).
	Not less than 6 rows (recirculating). Not less than 8 rows (100% outside air).

2.3 HEATING COILS (HOT WATER)

A. General: round seamless copper tubes are to be rolled into headers to form a permanent pressure tight joint. Coils are to be self-venting type. A vent connection is to be provided in the supply header and a drain connection in the return header. Coil Finned tube shall be fabricated to permit expansion without transmitting stresses to casing. Provide even distribution of steam or water to each tube. Preheat coils must be of the non-freeze type (tube within a tube).Each Coil to bear the seal indicating manufacturer's compliance with ARI Standard 410.

B. Headers: constructed of close-grained gray cast iron, heavy wall copper or steel pipe. Provide cleanable type headers.

C. Fittings: return bends and expansion bends to be fabricated from 5/8" O.D. or 1" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to or greater than the tube wall thickness.

D. Fins: aluminum or copper plate type or helically wound on the tubes. The plate type fins shall be continuous across entire coil width. Provide efficient bond between fin and tube, making each fin perform as an integral part of the tube.

E. Casing: zinc coated, rust resistant steel, with provisions for fastenings to duct work or for fastening coil sections together.

F. Testing: before shipment, coils are to be subjected to a 250 psig minimum air test under water or 1-1/2 times working pressure, whichever is greater.

G. Operating Limits: coils are to be designed, tested and guaranteed for operation with steam or water pressure and temperature as per system pressures for valves and fittings.

H. Coil Performance: all data pertaining to coil performance are shown on drawings. Pipe all coils counterflow. All water coils to have not more than 6 feet/second water velocity.

I. Coil Installation: preheat coils (any coil subject to freezing) must be installed to provide a minimum of 1/4" per foot of pitch towards the return (drain) point.

Heating Coils: Not more than 10-1/2 fins per inch.
Not more than 2 rows.

Reheat Coils: Not more than 8 fins per inch.

2.4 ELECTRIC DUCT HEATING COILS:

A. Furnish and install approved electric strip heater assemblies of the open coil, "slip in" type, in horizontal ducts or air handling units or casings as part of the mechanical work. All coils shall be of the highest grade resistance wire (80% nickel, 20% chromium, 0% iron) mounted in a braced aluminized or galvanized iron frame with stainless steel terminals which are insulated with high temperature phenolic or ceramic bushings. Coil shall be factory supplied with approved protective mesh non-corrosive screens. All assemblies, accessories, and installation shall be in conformance with applicable codes and shall bear the UL label.

B. Heaters shall be UL listed for zero clearance to combustible surfaces and for use with air conditioning equipment.

C. Each strip heater assembly shall be full duct size less any interior lining, and be located where shown and shall have the total wattage rating indicated. Provide approved, upstream and downstream, duct hangers within 12" horizontally of the heater.

D. Each strip heater assembly shall have its elements factory wired so that, based on total wattage (without regard to stages), they present line terminal characteristics as follows:

Watts	Volts	Phase	Wires
0-3000	277	1	2
3001-5000	480	1	2
5001 and up	480*	3	3

* Heaters for 480V, 3 phase, 3 wire characteristics shall be internally wired to balance the load on phase legs.

E. Each strip heater assembly shall have its elements factory wired so that, based on total wattage (without regard to stages), they present line terminal characteristics as follows:

Watts	Volts	Phase	Wires
0-1300	120	1	2
1301-2500	208/120*	1	3
2501 and up	208/120**	3	4

* 120 V. for control circuit only.

** Heaters for 208/120 V., 3 phase, 4 wire characteristics shall be internally wired to balance the load on phase legs.

F. Characteristics of control circuit shall be 2-wire, 120 volt, single phase.

G. Furnish as part of the strip heater assembly, an end mounted dust-tight terminal box, with removable cover, of sufficient size to properly contain specified appurtenances of this paragraph. Terminal box shall be insulated on the coil side for condensation purposes and shall have suitable ventilation openings. All wiring, control and power shall be factory installed to terminals such that field wiring by the electrical trade shall be limited to power connections and extensions of the control terminals to the room thermostat and sail switch.

1. Furnish a built-in disconnect switch with door interlock to protect service personnel.

2. Furnish for each strip heater assembly, an approved fused, factory mounted, wired control transformer rated for primary operation at not less than the heater assembly line to line voltage.

3. Furnish, for each strip heater assembly, a factory mounted, wired, approved, normally-closed, first contingency thermal cut out device of the auto reset type for operation at control voltage.

4. Furnish, for each strip heater assembly, stage, or circuit, an approved factory mounted, wired (in series with each heater circuit), normally closed, second contingency thermal cut out device of the manual reset type. Device shall be serviceable through terminal box without pulling heater assembly.

5. Furnish, for each strip heater assembly, stage, or circuit, an approved factory mounted, wired, magnetically held, electrically operated mercury type contactor with one full capacity contact for each line terminal of the heater, stage or circuit and a holding coil suitable for control voltage operation.

H. Electrical - Heaters shall be furnished rated for the voltage, phase and number of heating stages indicated in the schedule. Three phase heaters shall have equal, balanced, three phase stages. All internal wiring shall be suitable for 105 C.

I. Control Options - Heaters shall be furnished with thermal cutouts, airflow switch magnetic contactors, for each heater stage, fuses and control circuit transformer.

J. The electric duct heater manufacturer shall furnish and install a multi-stage controller, factory mounted and wired in the electric duct heater terminal box.

K. The electric duct heater manufacturer shall furnish and install a proportional power controller factory mounted and wired in the electric duct heater terminal box, to modulate the entire heater load directly, varying the heater output from 0 to 100% of total heater KW. Provide electronic thermostat for modulating control.

L. Provide remote panelboards where scheduled.

M. Where the duct heater is located in a mechanical equipment room, it will be interlocked with the associated fan so that the heater is de-energized when the fan shuts down. Wiring for this interlocking will be by this trade.

2.5 PRE-HEAT COILS (VERTICAL TUBE INTEGRAL FACE AND BY-PASS - VIFB)

A. General: Furnish ARI Certified Wing VIFB Heating Coils type: Steam for horizontal air flow. Each VIFB Coil to bear the seal indicating manufacturer's compliance with ARI Standard 410.

B. Each heating coil to consist of built-in series of finned heating elements and by-passes with interlocked dampers. Manufacturer to furnish coil complete with dampers, pneumatic damper motor(s), transformers (if required), pilot positioners and airstream thermostats. Dampers are to be arranged so as to completely enclose and isolate the heating coil passes when no temperature rise is required. Each coil shall be capable of maintaining a constant discharge air temperature regardless of variations in entering air temperature with full steam pressure (or hot waterflow) on the coil at all times.

Proportioning of the air shall be such that the temperature at any point in a plane parallel to the face of the coil three feet downstream from the leaving side will not vary more than 5°F from the average discharge airstream temperature.

C. Dampers shall be 16 gauge roll formed, cold-rolled steel with an air dried machine enamel finish.

D. Tubes seamless deoxidized copper, 5/8" O.D. and 0.020" minimum wall thickness. Each tube shall be individually secured to the steam and return headers by a mechanical joint consisting of a nut and ferrule compression union (to allow for individual removal of tubes in the event of damage.) with provision for individual tube expansion and contraction. Coil finned tube shall be fabricated to permit expansion without transmitting stresses to the casing. Tubes shall be secured against vibration by a channel-shaped retainer, permitting expansion and contraction.

E. Pressure drop of air through the coil shall not vary more than ±5%, regardless of the position of the internal dampers.

F. Headers: constructed of heavy wall copper, having pipe threads for supply and return connections.

G. Fittings: return bends and expansion bends to be fabricated from 5/8" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to or greater than the tube wall thickness.

H. Fins: aluminum or copper plate type. The plate type fins shall be continuous across entire coil width. Provide efficient bond between fin and tube, making each fin perform as an integral part of the tube.

I. Casing: zinc coated, rust resistant 14 gauge steel, with connecting flanges for fastenings to duct work or for fastening coil sections together.

J. Testing: before shipment, coils are to be factory tested at 200 psig steam pressure and 500 psi hydrostatic pressure or 1-1/2 times working pressure, whichever is greater.

K. Operating Limits: coils are to be designed, tested and guaranteed for operation with steam or water pressure and temperature as per system pressures for valves and fittings.

L. Coil Performance: all data pertaining to coil performance are shown on drawings. Pipe all coils counterflow. All water coils to have not more than 6 feet/second water velocity.

M. Coil Installation: Steam mains , return mains, water mains and traps should be anchored and supported independently of the coil. Steam supply piping should incorporate swing joints. Return piping must incorporate a flexible connection.

Pre-Heating Coils: Not more than 10 fins per inch.

2.6 REFRIGERANT COILS

A. Description: Direct Expansion Air coil designed to conform to ANSI B9.1 (Safety Code for Mechanical Refrigeration) and fabricated to ARI 410.

B. Direct expansion coils shall be constructed of 5/8 inch O.D. seamless copper tubing (min. 0.02" thick) with continuous aluminum fins, (maximum 12/inch) mechanically bonded to the tubes. Tube bends shall be the long radius type. Coils shall be leak tested at 300 psig air pressure under water, completely dehydrated and pressure tested with refrigerant.

C. Coil shall be multi-circuited with circuits intermixed across the full face of the coil, such that the full face of the coil is activated at part load in order to achieve good dehumidification performance by preventing bypass of air.

D. Each refrigerant circuit shall have its own high performance expansion valve capable of a large degree of capacity modulation without slugging. Coil shall have equalizing type vertical distributor to insure that each refrigerant circuit receives the same amount of refrigerant.

E. Drain pan: All cooling coils to have 316 stainless steel drain pan. Drain pan to be installed under coil and extending a minimum of 18" past end of coil. Pan to be drained with piping leading to floor drain.

Coils installed in more than one section high to have intermediate pans. Each pan to be individually drained with piping to outlet pipe leading to floor drain.

Insulation - ½" closed cell plastic, coated with an asphaltum binder cemented to inside surface with waterproof adhesive.

Multiple coils in air handling units to be provided with built in troughs.

F. Gutter: Stainless steel conforming to ASTM.

G. Moisture Eliminators: No water carry-over from cooling coils into air stream accepted. Eliminators shall be provided where required by unit manufacturer. Pressure drop across eliminator shall be maximum 0.25" W.G. at 350 FPM, coil face velocity.

H. Accessory: Moisture eliminator.

I. Ratings: Coils design tested and rated according to ASHRAE 33.

J. Source Quality Control: Leak test to 400 psig (2758 kPa) under water. Vacuum test coils at 180 deg F (82 deg C) and at 0.11 inches of mercury, absolute (371 Pa).

2.7 HEAT RECOVERY COIL

A. General: Heat recovery system shall utilize glycol solution containing 30% propylene glycol and water. All coil ratings shall be certified by A.R.I. Coils to have continuous water circuits from the inlet header to the outlet header. All joints in the water circuit are to be brazed. Coils are to be of the self-venting type. A vent connection is to be provided in the supply header and a drain connection in the return header. Each drain and vent outlet to be fitted with a hose-end valve, packless type, and a pipe cap. Each coil to bear the seal indicating manufacturer's compliance with ARI Standard 410.

B. Headers: constructed of heavy wall copper. Provide cleanable type headers.

C. Tubes: seamless deoxidized copper, 5/8" O.D. minimum and .020" minimum wall thickness. With the specified circuiting, water velocity not to exceed 6 feet per second.

D. Fittings: return bends to be fabricated from 5/8" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to .020" or greater.

E. Joints: tube joint between fittings and tubes; and tubes and header to be brazed.

F. Fins: plate type. Aluminum fins standard. Copper fins mandatory on sprayed coils. The plate type aluminum fins shall be continuous across the entire width and depth of the coil section and the tubes shall be mechanically expanded into the fins.

G. Casing: Stainless Steel top and bottom casing flanges are to be formed into a box shape for strength and durability, with a flat surface for coil stacking. Tube support sheets to be stainless steel.

H. Testing: before shipment, coils to be subjected to a 350 psig air test under water or greater as required and price be guaranteed for 200 psig working pressures.

I. Operating Limits: coils to be designed, tested and guaranteed for operation with water pressure and temperature required by specific job application. Conform pressures designated for valves and fittings.

J. Drain Pan: All coils to have 316 stainless steel drain pan. Pan to be installed under coil and extending a minimum of 18" past end of coil. Pan to be drained with piping leading to floor drain.

Coils installed in more than one section high to have intermediate pans. Each pan to be individually drained with piping to outlet pipe leading to floor drain.

Insulation - ½" closed cell plastic, coated with an asphaltum binder cemented to inside surface with waterproof adhesive.

Multiple coils in air handling units to be provided with built in troughs.

K. Coil Performance: all data pertaining to coil performance are shown on drawings. All coils shall be piped counterflow.

L. Exhaust heat recovery coil shall be coated with a minimum of 5 coats of baked epoxy phenolic by Heresite or Electro Fin.

M. Coil height shall not exceed 54".

N. Coil Limitations:

Heat Recovery coils	Not more than 10-1/2 fins per inch
	Not less than 8 rows

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and units to receive air coils for compliance with requirements for installation tolerances and other conditions affecting performance of the air coils. Verify piping rough-in dimensions. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install air coils and duct heaters as indicated, level and plumb, and according to manufacturer's written instructions, rough-in drawings, the original design, and referenced standards.

B. Install air coils and duct heaters in metal ducts and casings constructed according to SMACNA "HVAC Duct Construction Standards."

C. All coils shall be factory installed on tracks for easy removal from the air handling unit. Units that require dis-assembly of the unit for coil removal are not acceptable. Install coils such that headers and return bends are enclosed by unit casings.

D. Anchor air coils in position using suitable supports.

E. Install piping connections, maintaining manufacturer's recommended clearances for service and maintenance of coils.

F. Install moisture eliminators as indicated.

G. Install shutoff valves at coil inlet and outlet connections.

H. Provide pneumatic air to VIFB coils.

I. Connect duct heaters and components to wiring systems and to ground as indicated and instructed by manufacturer. Tighten connectors and terminals, including screws and bolts, according to equipment manufacturer's published torque-tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals according to tightening torques specified in UL 486A.

J. Provide for all code required clearances.

3.3 ADJUSTING

A. Comb bent fins on each air coil.

3.4 CLEANING

A. After completing system installation, including duct and fittings, clean coils using materials and methods recommended by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

END OF SECTION 15790

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15880 - METAL DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes all the rectangular, round and flat-oval metal ducts and plenums for the complete heating, ventilating and air conditioning systems in all pressure classes. In addition, this section includes the following:

1. Sheet Metal
2. Round and Flat Oval Ducts
3. Flexible Air Duct
4. Kitchen Range Ductwork Air Casings and Plenums
5. Dampers for Balancing
6. Access Doors in Sheet Metal Work
7. Inspection Portholes
8. Pressure Sensitive
9. Flexible Connections
10. Air Intakes and Discharges
11. Refer to other Division 15 sections for air distribution devices and accessories required in conjunction with this work.
12. Leakage testing, Air Distribution System.
13. Underground Ductwork

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Section 15010 - Basic Mechanical Requirements.
2. Section 15050 - Basic Mechanical Materials and Methods.
3. Section 15250 - Mechanical Insulation.
4. Section 15882 - Air Distribution Devices.
5. Section 15950 - Building Management and Controls.
6. This section is a part of each Division 15000 Section.
7. Division 16 - Electrical.

1.3 REFERENCES

A. SMACNA.
B. ASHRAE.
C. NFPA.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS.D1.1 “Structural Welding Code - Steel” for hangers and supports and SWS.D9.1 “Sheet Metal Welding Code.”

B. Qualify each welder in accordance with AWS qualification tests for welding processes involved. Certify that their qualification is current.

C. NFPA Compliance: Comply with the following NFPA Standards:

1. NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems,” except as indicated otherwise.
2. NFPA 96, “Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors for Commercial Cooking Equipment,” Chapter 3, “Duct System,” for kitchen hood duct systems, except as indicated otherwise.

D. SMACNA - HVAC Duct Construction Standards, Latest Edition.

E. SMACNA - “Guidelines for Welding Sheet Metal”.

F. The contractor must comply with the specification in its entirety.

G. At the discretion of the Owner, sheet metal gauges, and reinforcing may be checked at various times to verify all duct construction is in compliance. If on inspections, changes have been made without prior approval, the contractor will make the applicable changes to comply with this specification, at the contractor’s expense.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Submit duct fabrication standards and methods of installation, in compliance with SMACNA and these specifications, for review by Architect. Clearly indicate the combination of metal gauges and reinforcement intended for each pressure classification. Duct fabrication shall not be allowed until a satisfactory review of this Standard has been performed.

C. Include product description, list of materials for each service, and locations.

D. Product data including details of construction relative to materials, dimensions of individual components, profiles, and finishes for the following items:

1. Duct liner.
2. Sealing Materials.
3. Fire-Stopping Materials.
4. Dampers, turning vanes, access doors, plenums, flexible connectors, etc.

E. Shop drawings from duct fabrication shop, drawn to scale not smaller than 3/8 inch equals 1 foot, detailing:

1. Fabrication, assembly and installation details, including plans, elevations, sections, details of components, and attachments to other work.
2. Duct layout for all areas of work, indicating pressure classifications and sizes in plan view. For exhaust duct systems, indicate the classification of the materials handled as defined in this Section.
3. Fittings.
4. Reinforcing details and spacing.
5. Seam and joint construction details.
6. Penetrations through fire-rated and other partitions.
7. AC unit, equipment, terminal unit, coil installations.
8. Hangers and supports, including methods for building attachment, seismic restraint, vibration isolation, and duct attachment.

F. Welding certificates including welding procedures specifications, welding procedures qualifications test records, and welders qualifications test records complying with requirements specified in “Quality Assurance” above.

G. Maintenance data for volume control devices, fire dampers, and smoke dampers, in accordance with Division 15 Section “Basic Mechanical Requirements” and Division 1.

H. Mechanical Contractor shall submit all fan room sheet metal ductwork shop drawings to the AC unit manufacturer prior to submission to engineer for review. AC unit manufacturer shall approve the air performance and acoustical performance of the AC units in the location and with the ductwork configuration and construction as shown on the shop drawings. AC unit manufacturer shall indicate approval directly on the ductwork shop drawing.

1.6 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply.

1. Seams: A seam is defined as jointing of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.
2. Joints: Joints include girth joints, branch and subbranch intersections; so-called duct collar tap-ins; fitting subsections, louver and air terminal connection to ducts; access door and access panel frames and jambs; duct, plenum and casing abutments to building structures.

1.7 SYSTEM PERFORMANCE REQUIREMENTS

A. Provide a duct system with minimum resistance to airflow. Take-offs shall be throated and transitions made as gradual as possible. 'Bullhead' or sharp take-offs are not acceptable. Branch take-offs shall be 45 deg entry type. Straight tap or butt flanged connections are not acceptable. Clinch lock connections are preferred.

B. The duct system design, as indicated, has been used to select and size air moving and distribution equipment and other components of the air system. Changes or alterations to the layout or configuration of the duct system must be specifically approved in writing. Accompany requests for layout modifications with calculations showing that the proposal layout will provide the original design results without increasing the system total pressure.

PART 2 - PRODUCTS

2.1 GENERAL

A. Duct dimensions indicated on drawings are clear, inside dimensions. The sheet metal dimensions shall be increased to accommodate internal liner where liner is required.

B. Drawings are diagrammatic and indicate the arrangement of the principal apparatus, ductwork and piping and shall be followed as closely as possible. All offsets, rises, drops, fittings and accessories are not indicated on drawings, but shall be provided as required to install system. Carefully investigate structure, finish conditions, and the work of other sections affecting sheet metal work, including work associated with testing, adjusting and balancing, in order to arrange all items accordingly. Provide best possible arrangement so as to provide maximum headroom and maintenance clearances.

C. In addition to sheet metal ductwork specified herein, furnish and install, or install as furnished by other sections, accessories and devices including air distribution devices, smoke detectors, plenums, canopy hoods, and blank-off panels at unused louver areas.

D. Furnish and install intake and exhaust plenums attached to louvers.

E. Except as noted, all reinforcement shall be external.

2.2 SHEET METAL

A. Duct systems other than range hood exhaust **(or fume hood exhaust)** shall be galvanized steel and shall comply with the pressure classifications following in compliance with Page 1-18 to Page 1-31 inclusive of SMACNA HVAC Duct Construction Standards, latest edition. Duct sealants shall have a U.L. label and shall have a flame spread rating not over 25, and a smoke developed rating no higher than 50 when in the final dry state.

Duct System	SMACNA Table No.	SMACNA Pressure Classification	SMACNA Seal Classification
All supply ducts on systems with VAV terminal boxes from fan discharge to box.	1-6	+3" W.G.	A

Duct System	SMACNA Table No.	SMACNA Pressure Classification	SMACNA Seal Classification
All supply ducts on systems with VAV terminal boxes from fan discharge to box.	1-7	+4" W.G.	A
All supply ducts on systems with VAV terminal boxes from fan discharge to box.	1-8	+6" W.G.	A
All supply duct on systems without VAV terminal boxes from fan discharge to diffuser, and all ductwork downstream of VAV boxes to diffusers.	1-5	+3 W.G.	B
All return ducts and exhaust ducts.	1-6	-3" W.G.	A
All fume hood, laboratory, isolation rooms and all other special exhaust systems.	1-8	-6" W.G.	A
All primary air supply ducts serving induction units from fan discharge to unit connection	1-9	+10" W.G.	A

2.3 ROUND AND FLAT OVAL DUCTS

A. Construction: In accordance with HVAC Duct Construction Standards as specified above.

B. Round ductwork shall be spiral seam construction. Gauges and fittings shall be in accordance with SMACNA Duct Construction Standard (as referenced above).

C. Elbows, tees and branch take-offs shall be made of similar material to round straight ductwork.

2.4 FLEXIBLE AIR DUCT

A. Flexible Air Duct:

1. Flexible air ducts shall be all metal construction consisting of a core of stranded triple lock metal flexible ducting for strength and airtightness. The ducting shall have applied at the factory a UL listed glass or mineral wool insulating blanket, sheathed in a UL approved seamless exterior vapor barrier jacket. Flexible air ducts shall be semi-rigid construction capable of being easily hand pre-formed into required elbows or offsets to suit job conditions without subsequent sagging or droop. Duct connections to equipment outlet collars shall be made in accordance with the duct manufacturer's recommendations. Flexible duct shall be Flexmaster 8M as manufactured by Flexmaster U.S.A. Corporation or approved equal.

2. The insulation material shall have composite fire and smoke hazard ratings of 50/25.
3. The flexible air ducts shall be rated for an operating temperature range of -40°F to +250°F and an operating pressure of 12" w.g.
4. The complete assembly shall have been tested by Underwriters Laboratories Inc. and given the listing 181 Class I duct material, and comply with NFPA 90A and 90B.
5. The joint shall consist of a triple lock that is mechanically performed without the use of adhesives to make a durable, airtight seam. A double lock is not acceptable.
6. Length of flexible duct shall be maximum 5 LF, but shall not exceed length dictated by local jurisdiction.
7. Bends shall be made with not less than 1 duct diameter centerline radius. Ducts should extend a few inches beyond the end of a sheet metal connection before bending. Ducts should not be compressed.
8. Cut duct to proper length to avoid sharp bends.

2.5 UNDERGROUND DUCTWORK

A. All underground ductwork installed in a direct bury application shall watertight fiber reinforced plastic (FRP) including all fittings.

B. The duct and fittings, as a finished composite, shall meet the Flame and Smoke requirements of a Class 1 duct per UL 181 and UMC 10-1. Performance shall be verified by an ASTM E-84 testing laboratory recognized by ICBO or IBC.

C. Wall thickness shall comply with SMACNA and PS 15-69 duct standards. The ductwork shall be furnished with the following minimum wall thickness:
1. 0.125" for ducts up to 20" in diameter
2. 0.187" for ducts 21" to 36" diameter
3. 0.25" for ducts 37" to 60" diameter

D. All underground ductwork shall be 1" insulated double wall construction.

E. Resin shall be isophthalic polyester, suitable for corrosion against all normal soil, backfill, and moisture conditions.

F. Inner Lining shall be UL listed Class 1 for flame spread and smoke developed.

G. Structural layer shall be filament wound of resin and glass to meet the specified working pressures and depths of burial requirements.

H. Fittings shall be fabricated from straight duct and have the same working pressure and will be corrosion and moisture resistant. Reducers shall be filament wound as specified for ductwork.

I. Field joints are to be water tight by using an internal galvanized sheet metal sleeve secured with screws. Joints shall then be of wet lay-up type in strict accordance with the manufacturers specifications. This includes thoroughly cleaning and sanding areas to be joined and using polyester resin and fiberglass mat.

J. Manufacturers:
   1. Perry
   2. Spundstrand
   3. Foremost
   4. Or approved equal

2.6 SPECIAL DUCTWORK CONSTRUCTION

A. Ductwork required to be removable shall be companion flanged SMACNA Type T-22 for ductwork constructed to SMACNA Metal Duct Standard and companion flanged in accordance with Industrial Standards for ductwork constructed to Industrial Standards.

B. Exhaust ductwork containing hazardous materials shall be stainless steel 316L, continuously welded and watertight.

C. Ductwork systems serving areas of high humidity shall be constructed of stainless steel 316L, with gauges in accordance with SMACNA Standards as referenced above. Ductwork shall be continuously welded and watertight. Pitch duct to low point drains. Pipe drains (1" copper drain line) to floor drains or utility sinks.

   1. Areas include

      (a) Exhaust ductwork exposed on roof.
      (b) Within 5'-0" upstream and 10'-0" downstream of duct-mounted humidifier.
      (c) Within 20'-0" of a shower area exhaust register/grille.
      (d) Within 20'-0" of a sterilizer area exhaust register/grille or equipment connection (stainless steel only).

D. Ductwork exposed to weather

   1. After exposed ducts and joints are sealed and tested as specified, apply over and around the same areas of possible leakage (joints), an approved sealer system. Ductwork outside the building shall be installed in a manner to result in no air leakage.
   2. Exposed supply and return air ductwork shall be insulated and weather-protected as specified under another section of this work. Insulate after the ductwork installation has been completed and tested.

E. Perchloric Acid Ductwork System

   1. Construct ductwork of stainless steel 316L, continuously welded and watertight. Pitch duct to low point drains. Pipe drains to floor drains or utility sinks.

F. Polyvinyl Chloride Coated Galvanized Steel Ductwork (PCD):

   1. Except where noted, comply with Galvanized Steel Ductwork. Factory coat interior and exterior with a 4 mil thick coat of fused polyvinyl chloride. Construct and install horizontal ductwork and fittings with longitudinal seam located on top of duct.
   2. Connections shall be corrosion resistant using stainless steel screws.

3. Manufacturers: Foremost, Tangent, United McGill

G. Double Wall Ductwork

1. Outer wall: comply with Galvanized Steel Ductwork as specified above. Insulation: 1 inch 3.0 lb. density fiberglass acoustical liner with fire resistant fiber bonding coating and a 1 mil vapor barrier on inside. Inner wall: perforated galvanized steel, 3/32" diameter perforations, overall open area of 23%. Tightly secure liner along all seams.
   (a) Manufacturers
      (1) United Sheet Metal Div.
      (2) United McGill, Acousti K-27

2. Duct sizes refer to inside clear dimensions.

H. Exhaust Stacks on Top of Exhaust Fan:

1. Construct stacks from same material as exhaust duct.
2. Stacks shall be self-supporting and constructed for wind velocities up to 100 MPH from all directions.
3. Fabricate stackhead as indicated on ACGIH Fig. 8-6 for vertical discharge stack. Refer to drawings for additional details.

2.7 AIR CASINGS AND PLENUMS

A. All air casings and plenums shall be constructed of No. 16 gage galvanized iron braced and stiffened on outside by means of 2" x 2" x 1/4" galvanized steel angles not to exceed 26" width, or with 16 gauge standing seam panels not to exceed 26" in width. Standing seams are to have additional right angle bend and shall be capped with No. 18 gage galvanized "U" cap over entire length of seam. All joints shall be caulked to make them airtight. The bottom of all air chambers at the floor shall be gasketed to prevent air leakage.

B. The plenum installation shall be capable of withstanding a positive or negative internal static pressure of 10" W.G.

C. See "Acoustical Treatment." Note that all casings and plenums are lined with 2" of acoustical insulation with an inner aluminum perforated liner, so as to result in double wall construction.

D. All air casings or transition sections on the discharge side of medium pressure or high pressure fans shall be airtight at coils by completely enclosing the coils in the casing.

E. Openings to ducts and pipes, connectors, flanges, etc., shall be suitably framed, with not less than 18-gauge galvanized steel.

F. Casings shall be supported on floor curbs. The bottom of all air casings at the floor and at any other connection to masonry shall be riveted to 1-1/2" x 1-1/2" x 1/8" galvanized steel angles which have been secured to masonry with expansion shields and caulked tight with cement.

G. Provide angles above and below access doors and frames for access doors. Doors shall be supplied to provide the necessary access. All doors shall have the 3 hinge connecting areas as well as the latch connecting area internally reinforced with 11-gauge plate. Each door shall be factory assembled with door and hardware attached and adjusted. Door latches are to be of the positive pressure type with inside push rod. All hinges shall be designed for the door leaf size and weight. See "Access Doors in Sheet Metal Work" for additional requirements.

H. This Contractor shall be responsible for any additional bracing required for stiffness including roof deck of casings. The roof deck shall be braced and supported from the ceiling slab, if required for stiffness.

I. The plenum structure shall be normally self supporting. Where roof spans and wall loadings require additional structural strength, it shall be furnished by heavier roof and wall joiners or additional structural members. Lolly columns can only be used with the prior approval of the Mechanical Engineer.

J. Finish, Metal Surfaces:
   1. All sheet metal surfaces subject to painting shall be prepared for painting including grinding, smoothing of welds, degreasing and filling as needed.
   2. All exposed sheet metal surfaces, after cleaning, shall be primed with a nitrocellulose modified phenolic prime coating to a dry film thickness of 0.6 mil minimum.

2.8 DAMPERS FOR BALANCING

A. Provide manual dampers for balancing the air systems, as specified in Section 15886.

B. Construction shall conform to latest SMACNA standards. When installing dampers in ducts to be insulated provide raised bracket for damper quadrant with height equal to insulation thickness.

C. Provide volume dampers in branch take-offs and in main branches and ducts of all ductwork systems (supply, return and exhaust)for properly regulating and balancing airflow to all terminal outlets, whether indicated on drawings or not.
   1. Volume dampers shall be controlled by an approved galvanized locking quadrant indicating the damper position.
   2. Volume dampers installed in ductwork that is to be insulated shall have extended activator/handle rods such that the adjustment of the damper handle will not disturb the insulation.
   3. Locate damper as far as possible from air outlet to avoid noise transmission.

D. Coordinate with G.C. for easy access to damper.

E. For inaccessible ceilings, as well as for specialty areas such as lobbies, etc., furnish remote damper actuator operable through face of nearest diffuser. Damper controller and cable shall be concealed above the ceiling. Similar to Bowden remote cable control system with Young regulator damper controllers. Balancing dampers shall include all necessary hardware to ensure compatibility with remote cable control system.

2.9 ACCESS DOORS IN SHEET METAL WORK

A. This Contractor shall provide suitable access doors and frames to permit inspections, operation and maintenance of all valves, all coils including reheat coils, controls, fire dampers, air monitors where applicable, automatic or motorized dampers, filters, bearings, traps, or other apparatus concealed behind the sheet metal work. All such doors shall be of double construction of not less than No. 20 gauge sheet metal and shall have sponge rubber gaskets around their entire perimeter. Doors in insulated ducts or insulated casings shall have rigid fiberglass insulation between the metal panels.

B. All access doors in sheet metal ducts shall be hung on heavy flat hinges and shall be secured in the closed position by means of cast zinc clinching type latches. Where space conditions preclude hinges, use four heavy window type latches. Doors into ducts shall in general not be smaller than 18" x 18" except for access door to fire dampers which will depend on size of fire damper. Submit samples for approval.

C. In no case shall access to any items of equipment requiring inspections, adjustment, or servicing require the removal of nuts, bolts, screws, wing nuts, wedges, or any other screwed or loose device.

D. Each sheet metal chamber shall have access doors for access to all parts of the system. Doors shall be fitted with cast zinc door latches, two per door. Latches shall be operable from both sides of casing. Hinges shall be extra heavy, zinc plated hinges, minimum of two per door. The doors shall be felted or provided with rubber gaskets so as to make them airtight. The doors shall be made with inner and outer shells 2 inches apart so that they may be properly insulated and properly operated. Doors shall be a minimum size of 20" x 48".

E. Access door gauges for kitchen exhaust systems shall be equal to duct gauge.

2.10 INSPECTION PORTHOLES

A. Provide viewing portholes at both sides of fan sections and return air mixing plenums at air handling units 20,000 CFM or larger (package or built-up) to allow for inspection of fan belts, inlet vanes, damper actuators, etc.

B. Portholes shall be 8" dia. or 6" x 4" made of 1/4" thick acrylic reinforced with flanges in both sides.

2.11 FLEXIBLE CONNECTIONS

A. All fan and air supply unit connections, both at inlet and discharge shall be made with flexible material so as to prohibit the transfer of vibration from fans to ductwork connecting thereto, without air leakage. The material between the clamps shall have sufficient slack so as to prevent tearing due to fan movement.

B. The flexible connections shall be a minimum of 12" long Material shall be mechanically locked to the outside helix. Use of adhesives to lock fabric in place is not acceptable. The helix is constructed of a corrosive resistant galvanized steel, formed and mechanically locked to the duct fabric on the outside to prevent tearing.

C. Flexible fabric ductwork shall be rated at 6" positive pressure and at 4" negative pressure.

D. Flexible metal duct shall be listed UL Class 1.

E. Flexible connections shall be fabricated from approved flame proofed fabric conforming to NFPA 90A. Asbestos cloth is not permitted.

F. Indoor installations shall be Neoprene or vinyl coated fabrics.
G. Outdoor installations shall use Hypalon coated fabric.

H. Manufacturers

1. Flexmaster, Type 8

2.12 AIR INTAKES AND DISCHARGES

A. Air intake and discharge louvres and screens in the facade of the building shall be furnished and installed under another contract.

2.13 BLANK-OFF PANELS FOR UNUSED LOUVER AREAS

A. Provide a minimum 20 gauge sheet metal blank-off panels for unused louver areas that are not enjoined or connected to an active plenum.

B. Exterior/visible face of blank-off panel shall be cleaned and painted flat black, prior to installation.

C. Provide safing consisting of 2" rigid insulation on an aluminum panel for all unused portions of the louver. Louver areas on mechanical drawings may be indicated in free area. Contractor to review architectural drawings to determine actual louver areas.

PART 3 - INSTALLATION

3.1 GENERAL SHEET METAL DUCTWORK INSTALLATION

A. The specifications refer to SMACNA standards, which shall be considered minimal. If local codes require other standards than described in SMACNA, local codes shall govern.

B. Ductwork shall be installed to true alignment, generally parallel or perpendicular to adjacent building walls, floors and ceilings, so as to present a neat and workmanlike appearance.

C. Provide necessary offsets, transitions and streamliners to avoid interference with the building construction, piping, or equipment. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

D. Provide fittings, branches, inlets and outlets in such a manner that air turbulence is reduced to a minimum.

E. Provide a duct system with minimum resistance to airflow. Take-offs shall be throated and transitions made as gradual as possible. 'Bullhead' or sharp take-offs are not acceptable. Branch take-offs shall be 45 deg entry type. Straight tap or butt flanged connections are not acceptable. Clinch lock connections are preferred.

F. Provide straight runs of ductwork at equipment, fans, coils, terminal boxes and humidifiers per manufacturer's recommendations.

G. Tees and laterals at 90 deg or round ducts shall be 45 deg lateral or 90 deg tee with oval to round tap. 90 deg tee fitting or 90 deg tap is not acceptable. Conical tees are acceptable.

H. Provide flexible connector where ductwork connects to fans, air handling units and other rotating equipment and where indicated on drawings.

I. Furnish and install manual dampers, fire dampers, registers, grilles, register boxes, access doors, sound traps, etc., as described elsewhere in the specifications and as required for a complete system, ready for operation.

J. Where fire and smoke dampers, automatic dampers or combination fire/smoke dampers are shown on drawings or are required, their selection shall be made so that the dampers of all ratings and types shall be of the nominal 100% face area type, with blade package and frame components out of the airstream (type B). These dampers shall include the required oversize enclosures that shall be sealed by the damper manufacturer for the appropriate duct pressure class into which they are installed. Such dampers shall have appropriate rectangular, flat oval or round duct collars to facilitate connection of mating ductwork. The Contractor shall be responsible for any additional sealing of duct collars and connections required to maintain the duct seal class requirements, but shall not jeopardize the UL breakaway connection.

K. Repair damaged galvanized surfaces with inorganic zinc rich paint.

L. Repair PVC coated steel ductwork where coating is damaged or exposed by connections.

M. Bellmouth fittings shall be constructed to match duct metered requirements as specified herein. Bellmouth connection to duct main shall be made with gasket, sheet metal screws and duct sealant.

N. Enclose dampers located behind architectural intake or exhaust louvers in a sheet metal collar and seal to building construction.

O. Air volume control on parallel flow branches shall be accomplished with branch dampers.

P. Install special equipment items in ductwork systems, including automatic dampers, thermostats, thermometers, airflow measuring devices and other related controls, according to manufacturer's recommendations or under the supervision of the manufacturer.

Q. All required supports, hangers, anchors, and guides shall be provided and installed by this contractor.

R. All ductwork; flues, register boxes, air chambers, dampers, and all auxiliary work of any kind, necessary to make the various air conditioning, ventilating and heating systems of the building complete and ready for operation, shall be furnished and installed.

3.2 DUCT SEALANTS

A. Sealant: Water based elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) specifically for sealing ductwork. Use products as recommended by manufacturer for low, medium or high pressure systems.

1. Manufacturers
   (a) Hardcast
   (b) United McGill
   (c) Polymer Adhesives
   (d) Ductmate

B. Provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable.

C. Tape: Use only tape specifically designated by the sealant manufacturer. SMACNA recommends that foil tape not be used and that pressure sensitive tape not be used on bare metal surface or on dry sealant.

D. All ductwork indicated on drawings is schematic. Therefore, changes in duct size and/or location shall be made where necessary to conform to space conditions, at no additional cost to the Owner.

E. Ductwork connected to intake or discharge louvers shall be galvanized steel, painted for the first 10 feet with bitumastic, pitched to a low point, and provided with a 1-1/2" copper drain piped by this trade to a building drain.

F. A snap lock seam shall not be permitted as a substitute for the Pittsburgh lock except for systems with pressure classification +1" and less and where longitudinal joints are sealed and riveted at corners.

G. Where the trade elects to use "Duct-Mate" for joints or similar product, PVC clips are not permitted (use metal) and all corners shall be bolted (boltless connectors are not permitted) except where local codes permit Duct-Mate joints as breakaway connection at fire dampers. Only gaskets manufactured by Duct-Mate are acceptable.

H. Use gasketed type joint when dissimilar metals are joined.

I. All ductwork unless otherwise noted shall be hung with 1 in. x 1/8 in. galvanized iron bands. Ductwork with cross sectional area under 4 square feet shall be hung on 8'-0 in. centers. For ducts with a cross-sectional area of more than 4 sq. ft. but not over 10 sq. ft. hangers shall be no more than 6 feet apart, and for ducts with a cross sectional area of more than 10 sq. ft. hangers shall be no more than 4 ft. apart. All hangers shall be bent (2" minimum) under the bottom as well as the sides and secured with sheet metal screws.

J. Where ducts are stacked they shall be independently supported as above or shall be supported on minimum 1¼" x 1¼" x 1/8" angle cradle hung by either 1¼" x 1¼" x 1/8" angles or 3/8" diameter threaded rod.

K. All ductwork shall be substantially built with approved joints and seams smooth on the inside and a neat finish on the outside. Duct joints as near air tight as possible, with laps made in the direction of air flow and no flanges projecting into the air stream. Ducts shall be adequately braced to prevent vibration. All angles shall be galvanized or shop painted with two coats of rust resistant paint.

L. Changes in shape and dimension shall conform to the following:

1. Increase and reduce duct sizes gradually. Limit transition angle (for each side) to the following:

   (a) For increases in cross-sectional area, the shape of the transformation shall not exceed 1" in 7".
   (b) For reductions in area the slope may be 1" in 4" but 1" in 7" is preferred.

M. Changes in direction shall conform to the following:

1. Unvaned elbow with throat radius not less than ½ the width of the duct.
2. Provide square elbows in rectangular ducts where radius elbows will not fit or where specifically noted on drawings. Square elbows with single thickness duct turns shall be as per SMACNA with 3-1/4" spacing, and are acceptable in ducts with not more than 2200 FPM air velocity. For higher velocities, use sweep type vanes.

N. Turning vanes shall be single blade turning vanes fabricated from the same material as the duct. Large radius vanes shall be used. The maximum unsupported vane length shall not exceed 36". Tab spacing shall be SMACNA standard. Vanes shall be welded to runners. Rail systems with non-standard tab spacings shall not be accepted. All tabs shall be used, do not skip tabs. Mounting rails shall have friction insert tabs which align the vanes automatically. Vanes shall be subjected to tensile loading and be capable of supporting 250 lbs when fastened per the manufacturers instructions.

O. Wherever it may be necessary to make provisions for vertical hangers of the ceiling construction passing through ducts, provide streamlined shaped sleeves around such ceiling construction hangers as to fully protect the duct from being punched with holes for the passage of such hangers. Any such streamlined sleeves shall be made air tight at top and bottom of ducts. In no case shall there be more than two

rods in any 9 sq. ft. area. No rods shall pierce ducts smaller than 12" in horizontal area. No hangers shall pierce high pressure ducts.

P. When floor shut-off dampers are shown on drawings their selection shall be made so that the frames and stops of such dampers are outside of the air stream, so as to provide a nominal 100% free area damper.

Q. Exact dimensions of register boxes must await approval of grilles, and exact locations shall be submitted for approval, otherwise any changes directed after installation shall be made without additional cost. All register boxes and other opening of the ductwork must be kept tightly closed during construction to keep out rubbish.

R. Provide temporary closures on open ductwork when installation does not proceed for more than one day to prevent construction dust from entering ductwork system.

S. Openings for pitot tubes traverses shall be fitted with neat, removable plugs or caps. As a minimum, openings shall be provided at every fan inlet and at other locations that are required for testing and balancing. Coordinate locations with testing and balancing scope of work.

T. Provide No. 16 USSG, 3/4" wire mesh screen over each open return duct in hung ceiling unless register or grille is shown.

3.3 SEISMIC

A. See Section "Seismic Design."

B. See "Foundations, Vibration Isolation, and Supports for Rigidly Supported Equipment (Seismic Design)."

C. All other equipment and ductwork shall be rigidly supported and provided with approved seismic restraints to maintain the equipment and ductwork in a captive attitude without excessive motion. All ductwork seismic restraints shall be installed with a maximum spacing to limit transmitted forces to the building structure to acceptable limits.

3.4 KITCHEN EXHAUST SYSTEM

A. Provide kitchen exhaust system to comply with all authorities having jurisdiction.

B. Provide black iron ductwork and accessories as described herein for range hood exhaust.

C. The duct riser shall be located in an independent masonry code approved shaft provided as part of the building structure.

D. Miscellaneous exhaust ductwork shall be galvanized steel except those portions of ductwork containing dishwasher exhaust shall be aluminum or copper.

E. Insulate kitchen exhaust system as described under another section of this work.

F. Provide wiring diagram to Electrical Trade showing the following:

1. Fan switch adjacent to hood will start stop fan.
2. A heat detector system provided by the kitchen equipment manufacturer will function to activate extinguishing system, and close fuel source or electric power source to ranges. With a chemical extinguishing system, do not wire to stop fan.

G. Provide openings in duct for fire control means. Location and size of openings to be coordinated with trade performing the work.

3.5 DUCTWORK CLEANER AND DISINFECTANT

A. Required chemical cleaning shall utilize all-purpose, biodegradable degreasing chemical.

B. Required chemical disinfecting shall utilize a biocide disinfectant such as Oxine A.D. to kill bacteria, mold, mildew, and fungus.

3.6 LEAKAGE TESTING, AIR DISTRIBUTION SYSTEM

A. General: Each air distribution system shall be tested for leakage before insulation is applied.
After portions of the Work are completed, the following tests shall be made in the presence of the Owner's representatives. Five (5) days advance written notice of the tests shall be given to the Owner, who in turn will notify other parties interested. Furnish all gauges, blowers, instruments, test equipment and personnel required for tests, and make all provisions for removal of test equipment after tests have been made.

B. Air Handling Systems:

1. Ductwork (+/-) 2.0" wg (or less) external static pressure class (see following schedule): Before insulation is applied, run fan at design static pressure and check all joints for all ductwork, risers and branches. (Whether accessible or inaccessible including ducts as shafts, above hard ceilings and those that will be made inaccessible by work of other trades).
2. Ductwork (+/-) 3.0" wg (or greater) external static pressure class (see following schedule): All ductwork, risers and branches shall be individually tested with a blower, orifice section and U-tube gauge board. Each riser and branch shall be isolated from the remainder of the system by means of seals, plugs, or caps.
The blower shall maintain the design pressure class (see chart below) pressure differential across the orifice plate. Leaks which cause an air loss greater than the permissible leakage rate, defined below and, noisy or whistling leaks, shall be repaired and a retest made.
3. All ductwork: Horizontal mains in the mechanical rooms, tenant spaces and service rooms shall be tested after all riser tests have been accepted (where required) and after risers have been connected to the mains but before the branches have been connected to the risers. Mains shall be tested as described for risers and branches.
4. After the acceptance of the tests by the Owner, the branches shall be connected to the risers and the ductwork shall be released for insulation.
5. Permissible leakage rates:

Duct System	Pressure Classification External Static Pressure	SMACNA Seal	SMACNA Leakage Classification
All supply ducts on systems with VAV terminal boxes from fan discharge to box.	+3" W.G.	A	6
All supply ducts on systems with VAV terminal boxes from fan discharge to box.	+4" W.G.	A	6
All supply ducts on systems with VAV terminal boxes from fan discharge to box.	+6"W.G.	A	3
All supply ducts on systems without VAV terminal boxes from fan discharge to diffuser, and all ductwork downstream of VAV boxes to diffusers.	+3"W.G.	B	12
All return ducts and exhaust ducts, where not used for smoke exhaust.	-1" W.G.	B	12
All return ducts and exhaust ducts if used for smoke exhaust.	-3" W.G.	A	6
All fume hood, laboratory, isolation room and all other special exhaust systems.	-6" W.G.	A	3
All primary air supply ducts serving induction units from fan discharge to unit connection.	+10"W. G.	A	3

3.7 UNDERSLAB DUCT INSTALLATIONS

A. Verify undamaged conditions of duct prior to enclosure with fill or encasement.

B. Install underslab ducts in accordance with SMACNA "HVAC Metal Duct Construction Standards.," Figures 3-11 and 3-12, as indicated.

C. Protect ducts from damage by powered vibrators and other equipment used in placement of concrete on or around ducts.

D. Provide temporary protection for duct openings.

3.8 SCHEDULE

A. See drawings.

END OF SECTION 15880

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15882 - AIR DISTRIBUTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes all components of the air distribution system (other than piping and ductwork - which is specified under another section of this work) including, but not limited to, diffusers, grilles, registers, terminal units, fans, fan coil units, etc.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: The following sections contain requirements that relate to this section:

1. Section 15010, Basic Mechanical Requirements.

2. Section 15050, Basic Mechanical Materials and Methods.

3. Section 15880, Metal Ductwork.

4. This section is a part of each Division 15000 Section.

5. Division 16 - Electrical

1.3 REFERENCES

A. SMACNA.

B. ASHRAE.

1.4 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air distribution devices, air outlets and inlets of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:

1. ARI Compliance: Test and rate air devices in accordance with ARI Standards.

2. ASHRAE Compliance: Test and rate air devices in accordance with ASHRAE Standards.

3. ADC Seal: Provide devices bearing ADC Certified Rating Seal.

4. AMCA Compliance: Test and rate air devices in accordance with AMCA Standards and shall bear AMCA Certified Rating Seal.
5. NFPA Compliance: Install air devices in accordance with NFPA90A "Standard for the Installation of Air Conditioning and Ventilating Systems."

6. UL Compliance: The complete device must be labeled and listed by UL and must be installed to meet their requirements.

7. All devices must be tested and approved for safety in accordance with the latest N.E.C.

1.5 SUBMITTALS

A. Product Data: Submit manufacturer's technical product data for air outlets and inlets including the following:

1. Manufacturer's technical product data, including performance data for each size and type of air distribution device furnished; schedule showing drawing designation, room location, number furnished, model number, size and accessories furnished and installation and start-up instructions.

2. Data sheet for each type of air outlet and inlet, and accessory furnished, indicating construction, finish and mounting details.

3. Performance data for each type of air outlet and inlet furnished, including aspiration ability, temperature and velocity traverses, throw and drop, and noise criteria ratings. Indicate selections on data.

B. Shop Drawings: Submit manufacturer's assembly-type shop drawings indicating dimensions, weight loadings, required clearances, and methods of assembly of components.

C. Wiring Diagrams: Submit ladder-type wiring diagrams for electric power and control components, clearly indicating required field electrical connections.

D. Maintenance Data: Submit maintenance data and parts list for each type of air terminal, including "trouble shooting" maintenance guide. Include this data, product data, shop drawings, and maintenance data in maintenance manual, in accordance with requirements of Division 1.

1.6 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver air distribution devices wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of device and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.

B. Store air outlets and inlets in original cartons and protect from weather and construction work traffic. Where possible, store indoors, when necessary to store outdoors, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS

2.1 AIR DISTRIBUTION DEVICES

A. Grilles, Registers and Diffusers

1. Contractor shall furnish and install where shown on the drawings all diffusers, grilles and registers of the sizes, types and capacities indicated.

2. Devices shall be aluminum or steel and shall be factory finished with baked white enamel finish or extruded aluminum finish.

3. All air distribution equipment shall be as manufactured by Anemostat, Nailor, Price Company, Carnes, Titus Mfg. Corp., Krueger or approved.

4. Equipment manufacturer shall submit engineering data in a manner to facilitate convenient review of the following factors:

(a) Throw, terminal velocity, noise criteria (NC), sound power, static pressure and total pressure of each type and size of air outlet. Maximum noise criteria selection for NC-35 spaces shall be 27 NC.

(b) Supply air units shall distribute the specified quantity of air evenly throughout the occupied zone uniformly, draftlessly and noiselessly. Sound levels shall not exceed ratings as required in the "Acoustical Treatment" section of these specifications.

(c) For devices installed in plaster construction, supply plaster frames as required for setting. All design and margin construction shall be coordinated with architectural requirements. Plaster frames where required shall be constructed of same material and finish as air terminal.

(d) The air outlet manufacturer shall review architectural plans and shall be responsible for furnishing all air outlets with frames and margins which will be compatible with ceiling construction.

5. Provide minimum 10 LF of ductwork between FPTU or VAV terminal unit and first air outlet.

B. Ceiling Diffusers

1. All ceiling diffusers shall be furnished and installed with an equalizing deflector and independent volume damper. Volume dampers installd in diffuser neck are not acceptable. If diffuser is to be used for return air, omit equalizing deflector. Supply diffusers shall be gasketed to prevent streakage, unless installed in T-bar or concealed spline ceiling. Blank-off or sectorizing baffles shall be furnished as indicated. Diffusers shall be aluminum or steel and shall be factory finished with baked enamel finish of color selected by Architect.

2. Diffusers shall be round, square, rectangular or linear as indicated and as listed herewith, or as approved.

(a) Circular Diffuser with round neck:
Shall be similar to:

Titus	-	TMRA-3
Carnes	-	DA-5
Anemostat	-	C-27
Krueger	-	RA-2
Price Company	-	RCD

(b) Square Diffuser with round neck:
Shall be similar to:

Titus	-	TMS
Carnes	-	SFA
Anemostat	-	E-1
Krueger	-	1400
Price Company	-	SCD

(c) Square or Rectangular Multi-Pattern Diffuser with square or rectangular neck:
Shall be similar to:

Titus	-	TDC
Carnes	-	K
Anemostat	-	DF
Krueger	-	SH
Price Company	-	AMD

(d) Diffuser one, two, three or four-way pattern discharge as shown on the plans.

(e) Perforated Face Diffuser with square or rectangular neck:
Shall be similar to:

Titus	-	PAS
Carnes	-	4300
Anemostat	-	PLDV
Krueger	-	4500
Price Company	-	PDS

For supply air to Type for return air.

(f) Slot Type Linear Diffuser:
Shall be similar to:

Titus	-	ML
Carnes	-	4800
Anemostat	-	SLAD
Krueger	-	1900 (1800)
Price Company	-	SDS

(g) Diffuser shall be constructed of extruded aluminum with quick positioning pattern control permitting 180 degree air pattern adjustment. Diffuser shall have independent volume dampers which operate separate from pattern control. Volume dampers installed in diffuser neck are not acceptable. Inner pattern control and brackets shall be black coated. Slot opening shall be as shown on plans.

(h) Linear Grilles:
Shall be similar to:

Titus	-	CT
Carnes	-	C
Anemostat	-	AL
Krueger	-	1500-1600
Price Company	-	LBD

3. Grilles shall be constructed of extruded aluminum with fixed extruded bars set at specified deflections. All sheetmetal plenums shall have 1" acoustical lining.

4. See drawings for diffuser and grille types not specified herein.

C. Grilles and Registers

1. Supply Air Registers:

(a) Shall be of the double deflection type with key operated opposed blade damper, similar to:

Titus	-	272RS5
Carnes	-	200V
Anemostat	-	SZVO
Krueger	-	880V-OBD
Price Company	-	520

(b) Supply air grilles shall be identical to above with omission of opposed blade volume damper.

2. Return and Exhaust Air Registers:

(a) Shall be of the fixed bar type, with blades set at either 0° or 45°, similar to:

Titus	-	23RL5
Carnes	-	600H
Anemostat	-	S3HOD
Krueger	-	S80H-OBD
Price Company	-	530

(b) Shall be furnished with independent key operated opposed blade damper. Volume dampers installed in diffuser neck/core are not acceptable. Return or exhaust grille shall be identical to above with omission of opposed blade damper, similar to Connor Type RFF.

3. Transfer Grilles:

   (a) Shall match return grilles in appearance, similar to:

Titus	-	23RL
Carnes	-	650H
Anemostat	-	234D
Krueger	-	S80H-OBD
Price Company	-	510

4. Accessories:

   (a) Where indicated, registers or grilles shall be provided with independent adjustable volume (volume dampers installed in grille neck/cove are not acceptable and directional control device, similar to:

Titus	-	AG 225
Carnes	-	800
Anemostat	-	TL-2
Krueger	-	VC-8
Price Company	-	AE

5. See drawings for diffuser and grille types not specified herein.

D. Perimeter Diffusers

1. Perimeter diffusers shall be of two (2) slot combination heating-cooling type suitable for overhead heating without exceeding stratification factor of 4.0 when handling CFM ranges shown on the drawings at a maximum discharge temperature of 90°F. Cooling air shall be at 18°dt and comfort conditions of velocity and room stratification factor shall be maintained below 3.0.

2. Diffuser face shall consist of one adjustable volume control and one adjustable direction vertical pattern factory set for proper angle but with adjustable locking device to facilitate field adjustment. Unit shall be of extruded aluminum construction throughout. Diffusers shall be of lengths indicated on drawings and complete with 1" acoustically lined sheetmetal plenum, having a maximum height of 7".

3. Diffusers shall be painted in flat black with center septum in off-white for installation on exposed ceiling T-Bars.

4. The diffuser manufacturer shall demonstrate (by laboratory mock-up) to the engineer and/or the Owner's representative complete diffuser performance of discharge angle, volume control, pressure drop and sound level.

5. Diffusers shall be Price Company KO-545 with a width not to exceed 5".

6. See drawings for diffuser types not specified herein.

2.2 VARIABLE PRIMARY AIR VOLUME SERIES FAN-POWERED TERMINAL UNITS (FPTU)

A. Furnish and install variable primary air volume series fan-powered terminal devices (FPTU) as indicated on the Drawings. The devices shall have duct connections as indicated as shown on the Drawings. The devices shall be provided with a primary variable air volume damper that controls the primary air quantity in response to a temperature control signal.

B. The devices shall contain a fan and motor assembly, and an hot water, heating coil where scheduled and/or indicated on the Drawings. The fan shall provide a constant volume of discharge air at all air blending ratios from minimum to maximum scheduled primary air quantities and zero to 100% return air flow rates and shall be controlled in sequence as outlined hereinafter. Fan shift shall be no more than 5% from full heating to full cooling.

C. Terminals shall be certified under the ARI Standard 880-94 Certification Program and carry the ARI Seal.

D. The terminal shall be designed, built, and tested as a single unit including motor and fan assembly, primary air damper assembly, water or electric heating coils, and accessories as shipped. Unit shall ship as a complete assembly requiring no field assembly (including accessories). All electrical components shall be UL listed and installed in accordance with the National Electric Code and local regulations. Electrical connection shall be single point. All electrical components, including low voltage controls, shall be mounted in sheet metal control enclosures. The entire terminal shall be ETL or UL listed as a complete assembly.

E. The space limitations shall be reviewed carefully to ensure all boxes will fit in the space allowed including National Electric Code clearances required in front of all panels containing electrical devices. Electric control panel to be mounted on front of FPTU (air discharge face) and coordinated with discharge duct based on sheet metal shop drawings to insure code clearances.

F. The terminal casing shall be minimum 20 gauge galvanized steel., internally lined with dual density glass fiber insulation which complies with UL 181 and NFPA 90A. Any exposed insulation edges shall be coated with NFPA 90A approved sealant to prevent entrainment of fibers in the air stream. The terminal shall have round or rectangular duct collar for the primary air connection and a rectangular discharge suitable for flanged duct connection. The casing shall be designed for hanging by sheet metal straps.

G. The terminal casing shall have a bottom access panel which allows removal of fan and servicing of terminal without disturbing duct connections.

H. The fan shall be constructed of steel and have a forward curved dynamically balanced wheel with direct drive motor. Motors shall be General Electric ECM variable speed dc blushless motors. Motor shall be complete with and operated by a single-phase integrated controller/inverter that operates the wound stator an senses rotor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Motor shall be direct coupled to the blower. Motor shall maintain a minimum of 70% efficiency

over its entire operation range. Provide isolation between fan motor assembly and unit casing to eliminate any vibration from the fan to the terminal unit casing. Provide anti-back rotation system or provide a motor that is designed to overcome reverse rotation and not affect life expectancy.

I. Provide a filter rack with a 1" thick throw-away filter to be used during construction. Refer to the Section titled "Air Filters" for additional requirements. Filter shall replaced by the Mechanical Subcontractor after construction period and prior to air balancing. Replace filter again after pre-occupancy flush.

J. Terminal unit manufacturer shall provide flow curves for primary air sensor and supply fan inlet sensor(s) clearly labeled and permanently attached on the bottom of each fan terminal.

K. The device shall include all equipment and controls as required to provide a complete and operating system with at least the following equipment and controls:

1. Single point electrical connection for the voltage/phase/amperage as scheduled on the electrical contract drawings. See electrical Drawings for power feed arrangements for each device.

2. Factory mounted on unit, fused disconnect switch sized to protect all device electrical components. For 3 phase units, single phase motors shall be from alternate phases so as not to imbalance the electrical system.

3. Individual electrical protection devices as required to protect individual devices and transformers as required for individual component voltages as required.

4. Provide a manual speed control system which shall allow continuously adjustable fan speed from a maximum to minimum as shown on the manufacturer’s fan curves. This speed control system will be used to set maximum fan speed on the fan for the initial cfm. Fan speed and cfm shall be verified after installation and reset after the air balance subcontractor has proportioned the air from the unit to the air quantities shown on the Drawings. Fan shift at unit set point shall be no more than 5 deg. F from heating to full cooling T-Stat set points.

5. Provide a multi-point flow sensor device that will limit the maximum primary cfm to the terminal unit to that indicated on the Drawings. A multi-point flow sensor shall be located in the primary duct connection and at each return air inlet. Provide a separate flow sensor in each return air to or the discharge air from the box for air balancing of the terminal unit. If two return air flow sensors are required for the design of the terminal unit they shall be piped together to a single set of ports located within or on the unit. Units with motor/blowers that can be balanced by a volt meter w/o feedback will only need primary sensors.

6. Provide a transformer with 24 volt AC secondary to provide power for the box controls. The multipoint flow sensors shall be capable of controlling the terminal unit discharge air volume (CFM) to within five (5) percent of scheduled design fan air volume (CFM). The VAV terminal unit manufacturer and the BMS Contractor shall verify compatibility of the primary air multipoint sensor with the transducer and DDC microprocessor

furnished under the BMS Section prior to bidding this Project. A test shall be conducted in an independent testing laboratory acceptable to the Engineer and Owner to prove compatibility and accuracy of the flow control system and the fan powered terminal device at various primary flow rates from 250 fpm to 3000 fpm and the accuracy of the discharge air volume (CFM). The test may be witnessed by the Engineer and Owner. Test results shall be submitted to the Engineer and Owner for review

7. The BMS Contractor shall provide a digital electronic differential pressure instrument to be used during air balance, which will be left with the building Owner's operators after air balance is complete.

8. Provide sufficient controls to allow for controlling the following functions.

   (a) All boxes: Air on, fan starts. Air off, fan stops

9. Room DDC thermostat connection to modulate primary damper **and** heating staging.

10. Coordinate with the BMS Section of the work.

11. The control sequence shall be as follows from full cooling to full heating:

    (a) Primary damper open to allow scheduled maximum primary air quantity and close to minimum primary air quantity.

    (b) Fan shall operate continuously when the primary air system is in operation as activated by DDC signal being sent to boxes and when the space temperature drops below 55°F.

    (c) The fan shall operate continuously for the cooling and heating cycle.

    (d) Modulate hot water heating coil control valve to meet heating requirements.

L. This contractor shall be fully responsible for coordinating the electrical power feed arrangements (voltage/phase/amperage) for the fan powered terminal boxes, as indicated on the electrical contract documents. In the event that the terminal boxes delivered to the site do not comply with the electrical feed arrangements, he shall be fully responsible for all costs incurred to remediate the situation.

M. The primary inlet shall be equipped with a gradual transition (SMACNA Construction Standards) as required to connect to the primary duct size shown on the Drawings. The transitions shall be provided and installed by the device manufacturer or field installed by this contractor. The transition shall provide at least a 4" length with a 1/8" high raised bead approximately 1-1/2" from the inlet connection.

N. The primary air and fan design CFM settings shall be clearly and permanently marked on the bottom of the unit along with the device identification numbers.

O. Fan motor assembly shall be a forward curved centrifugal fan with a direct drive motor. Motors shall be General Electric Energy Saver ICM2+. All motors shall be DC and brushless. Motor shall be complete with and operated by a single phase integrated controller/invertor that operates the wound stator and senses rotor

position to elicrically commutate the stator. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall have built-in soft start and soft speed change ramps. Motor shall be able to be mounted with shaft in horizontal or vertical orientation. Motor shall be permanently lubricated with ball bearings. Sleeve bearings will not be acceptable. Motor shall be direct coupled to the blower. Motor shall maintain a minimum of 70% efficiency over its entire operating range.

P. Provide isolation between fan motor assembly and unit casing to eliminate any vibration from unit casing. Provide anti-back rotation system or provide a motor that is designed to overcome reverse rotation and not affect life expectancy. Motor wiring shall incorporate a UL listed plenum rated quick disconnect electrical coupling for ease of fan removal.

Q. VAV Terminal Device Hot Water Heating Coils:

1. Hot water heater coils shall be integral to the unit, not an add on.

2. The heating coils shall be constructed and installed in accordance with the requirements of the local Authorities and shall be ETL listed as component of Box.

3. The heating coils shall be fabricated from round seamless copper tubes rolled into headers to form a permanent pressure tight joint. Coils are to be self-venting type. A vent connection is to be provided in the supply header and a drain connection in the return header. Coil Finned tube shall be fabricated to permit expansion without transmitting stresses to casing. Provide even distribution of water to each tube.

4. Headers: constructed of close-grained gray cast iron, heavy wall copper, having pipe threads for supply and return connections.

5. Tubes: seamless deoxidized copper, 5/8" O.D. or 1" O.D. and 0.020" minimum wall thickness.

6. Fittings: return bends and expansion bends to be fabricated from 5/8" O.D. or 1" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to or greater than the tube wall thickness.

7. Fins: aluminum or copper plate type or helically wound on the tubes. The plate type fins shall be continuous across entire coil width. Provide efficient bond between fin and tube, making each fin perform as an integral part of the tube.

8. The coils are to be designed, tested and guaranteed for operation with steam or water pressure and temperature as per system pressures for valves and fittings.

9. Coil Performance: all data pertaining to coil performance are shown on drawings. Pipe all coils counterflow. All water coils to have not more than 6 feet/second water velocity and not more than 8 fins per inch.

10. Heating coils shall be provided with automatic control valves and shall be designed for operation with the DDC controller and control system as specified in the BMS section.

11. Shop Drawings shall be submitted for review as specified. These Shop Drawings shall indicate specifically the exact construction, materials, etc., of the heating coils to be furnished under these Specifications.

R. The primary air damper shall be of a design that shall vary primary air supply in response to an electronic signal. Damper leakage at shutoff shall not exceed 2% of the scheduled maximum fan cfm at 1.5" w.g. Submit damper leakage test data to the Engineer for review.

S. Damper operation shall be demonstrated to be closed to minimum position before the hot water, electric heating coil is allowed to operate. No overlap under any conditions will be allowed. Damper shall be located inside the unit.

T. Damper connection to the operating shaft shall be a positive mechanical connection to prevent any slippage. Motor operator shall have sufficient torque to operate damper smoothly through its full range with close off within specified leakage. Manufacturer shall submit a life cycle test report on damper and motor assembly from a certified independent laboratory of a minimum of 10,000 cycles from full open to full close without failure of any part of motor or damper. Provide non-lubricated delrin, nylon, teflon or mylar bearings for the damper shaft.

U. The primary air damper in conjunction with the DDC microprocessor shall be selected to provide control at low primary air velocities. The total deviation in primary air flow shall not exceed ± 5% of the primary air CFM corresponding to a 250 fpm air velocity through the primary air valve at 0.2 to 2" w.c. inlet static or alternate low flow control logic to offset low flow deviation, subject to Engineer's approval.

V. The primary air flow fidelity shall be laboratory demonstrated and proven with any inlet configuration and inlet static variation from 0.2 to 2.0 inches w.g.

W. A mixing chamber to provide mixing of primary air and fan air from 100% primary air to 0% primary air, with a temperature variation four feet downstream of the device as specified hereinafter.

X. Provide duct inlet connections of minimum straight length and size as recommended by unit manufacturer.

Y. Acoustical Requirements

1. Sound attenuation of air stream noise and acoustical treatment of device shall comply with the following with 1" W.G. inlet pressure, 0.25" W.G. discharge pressure, and the specified design air volume scheduled on the Drawings. Radiated noise and discharge noise readings shall be recorded at 0.5" W.G., 1.0" W.G., and 1.5" W.G. inlet static pressures.

2. Limit the terminal unit radiated noise as follows:

(a) All occupied tenant spaces and public areas shall be equal to or less than NC 35 when installed above the ceiling material specified in another Division of the Specifications.

(b) Every size unit at the scheduled design conditions shall be sound

laboratory tested prior to bid date for this project in a mockup of a typical 15' x 15' tenant office. The laboratory mockup test shall use the specified ceiling light fixture, Project ceiling height, Project ceiling plenum depth, and typical ductwork. The terminal units shall be mounted directly above the lighting fixtures at the height indicated on the Drawings. The test will be conducted in accordance with test procedures approved by the Engineer and the acoustical consultant to demonstrate compliance with the NC acoustical criteria within the tenant space.

(c) If the VAV fan-powered terminal unit manufacturer has conducted the hereinbefore specified acoustical mockup test and compatibility test with the DDC controller, and with this project's typical conditions, and has demonstrated to the Engineer and general contractor compliance with the specified acoustical performance and compatibility, the previous testing will be accepted and will not need to be repeated. If submitting previously conducted test data, the manufacturer shall certify that such tests have been conducted within the past 2 years. Non-compliance with these criteria shall require testing for this project. Mockup tests will be witnessed by the Engineer and general contractor and the acoustical consultant.

(d) Treatment to limit the noise to an amount that will not produce more than a sound level as specified above when installed in the duct system as indicated on the Drawings. The rectangular ductwork system downstream of the terminal devices is lined with ½" thick, 2 lb. density duct, with perforated inner liner, for the lengths as specified on drawings.

3. Unit maximum radiated sound power levels as published by the manufacturer with 1-1/2 inches w.g. inlet pressure and the specified design air flow scheduled on the drawings shall be as follows:

Octave Band Mid Frequency Hz	Maximum PWL (DB RE: 10-12 Watts)
125	66
250	61
500	60
1000	59
2000	58
4000	56

Z. The entire assembly shall be enclosed in a galvanized sheet metal (not less than 20 gauge) double wall housing of sufficient rigidity so that it does not vibrate due to action of the turbulent air on the panels of enclosing metal. This requires minimum 20 gauge sheet metal and stiffeners. Double wall terminal units shall have a 20 gauge galvanized outer sheet and a 22 gauge solid galvanized inner sheet over a structural steel frame. The unit shall have 16 gauge corners for mounting.

AA. The entire casing assembly upstream of the primary air valve shall be capable of withstanding a maximum static pressure of 3.0" W.G. All casing joints upstream of the primary air damper or valve shall be sealed with approved adhesive to meet the maximum leakage rate specified herein.

BB. Thermal and Acoustical Insulation

1. Thermal and acoustical insulation for all portions of the device shall be double density acoustical insulation and fully covered with solid sheet metal inner panels. No lining shall be in contact with the air stream.

2. The insulation shall meet or exceed a thermal conductance of 0.24 Btu per inch per hour per square foot per °F at 75°F. The fire-resistant coating shall bind the surface fibers tightly to prevent any fibers from becoming loose. The insulation, facing, adhesive and lining shall have a composite fire and smoke hazard rating as tested by procedure ASTM E84, NPA 225, and UL 723 not exceeding: Flame Spread 25, Smoke Developed 50. Adhesives, mastics and cements shall have the same component ratings listed above. No insulation shall be exposed to the moving air stream.

CC. Mounting connections for hanging the device by sheet metal straps shall be clearly identified on the housing. Casing at mounting points shall be minimum 16 gauge. All components, including all controls, and all wiring shall be factory installed. No field assembly will be allowed. The device shall be complete to accept the following field adjustments:

1. Primary duct.

2. Secondary duct.

3. Electrical connection.

4. Room thermostat connection to modulate the primary air damper and heating staging.

DD. The primary system is designed to provide at least 0.05" W.G. at the inlet to the terminal device. All downstream static pressure requirements are to be supplied by the FPTU fan.

EE. Laboratory Testing

1. Each size of each device to be used on this Project shall be completely laboratory tested for air performance and acoustics. The acceptability of any other laboratory and testing facilities is subject to review by the Owner and the Engineer. The device manufacturer shall submit complete details, brochures, instrumentation information, etc., for review. The laboratory shall be capable of properly testing the largest device on this Project. The air volume listed on the Drawings for this device shall be supplied for the test with the cold duct supplying 48°F air and the bypass space supplying 80°F air.

(a) At primary air damper or valve positions as indicated hereinafter and with an inlet static pressure of 0.50" W.G. and 1.0" W.G. the mixing device shall be capable of producing a mixed air stream of which the temperature shall not vary more than 1.0°F over the duct 48" downstream of box for each 12°F temperature between the temperatures of the entering warm and cold air. The variation of temperature shall be proportionally less at smaller temperature differences. There shall be at least fifteen temperature readings made at the discharge outlet duct over the entire discharge area with the air entering the device in each of the following proportions:

(1) 25% cold air and 75% hot air.

(2) 50% cold air and 50% hot air.

(3) 75% cold air and 25% hot air.

(b) Operating of the flow control device shall be demonstrated to repeat under all conditions of operation of the primary air damper or valve and duct pressures as specified hereinbefore. If the VAV fan-powered terminal unit manufacturer has conducted the hereinbefore specified air performance and air mixing tests and has demonstrated to the Engineer and general contractor compliance with the specified criteria the previous testing will be accepted and will not need to be repeated. The engineer and general contractor reserve the right to retest a production terminal at the terminal unit manufacturers cost upon two weeks written notice. The engineer or general contractor shall select the terminal unit of their choice.

(c) After the manufacturer has submitted six certified copies of the laboratory test results to the Engineer, the Engineer may witness the laboratory tests to verify compliance with the Specifications.

FF. Factory Testing

1. The FPTU manufacturer shall verify the operation of each fan powered terminal before shipment. Testing shall include the following:

(a) Apply electric power to the unit.

(b) Start the fan and verify fan rotates properly. Verify amp draw.

(c) Adjust the variable speed controller from maximum to minimum setting. Verify the reduction of fan speed. Upon verification, reset the variable speed controller to its maximum setting or set fan for jobsite CFM specified.

(d) Energize the electric heat through the electric heating coil relay. Verify the signal with a volt meter to insure proper heater operation. Verify amperage of each stage of heating.

(e) De-energize the electric heating coil and verify the signal with a volt meter to insure the heater is de-energized.

(f) Disconnect the primary air damper actuator from the DDC terminal unit controller. Provide separate power source to the actuator to verify operation and rotation of damper. Drive the damper closed and verify by feel or observation that damper is driven fully closed.

(g) Hot Water Heating coils are to be subjected to a 250 psig minimum air test under water or 1-1/2 times working pressure, whichever is greater.

(h) Provide a written inspection report for each terminal unit signed and dated by the test technician verifying all terminal unit wiring and testing (including the DDC terminal unit controller) has been performed as described herein and as per the manufacturers testing and quality assurance requirements.

2. Construction Inspection:

(a) Sealant applied to seams upstream of the primary damper.
(b) Bolts and rivets secure.
(c) Liner firmly attached.

GG. The VAV fan powered terminal devices shall not contain asbestos and shall be so certified to the Engineer.

HH. The BMS contractor shall furnish the FPTU Unit Controller (UC) and flow transducers (if not integral with the UC and damper actuator) to the FPTU manufacturer's factory. The BMS contractor shall supply written instructions and drawings containing sufficient information to enable the FPTU manufacturer to undertake the installation satisfactorily.

II. The BMS contractor shall visit the FPTU manufacturer's facility shortly after the commencement of installation to ensure that the FPTU manufacturer's installation procedures are satisfactory. The FPTU manufacturer shall prepare a drawing of the wiring for the FPTU unit controller and all associated instrumentation and final control elements based on the information provided by the BMS contractor.

JJ. The FPTU manufacturer and the BMS contractor shall both certify on the drawing that the drawing is correct and the drawing shall be submitted as a shop drawing for the approval of the Owner and Engineer. The BMS contractor shall visit the FPTU manufacturer's facility at the completion of installation, prior to the shipping of any FPTU to the project site, to inspect the installation of the UC. The FPTU manufacturer shall not make any adjustments to the FPTU unit controller, enter any data into the FPTU unit controller in any way. All testing, entry of data and adjustments of any kind to the FPTU unit controller shall be undertaken by the BMS contractor at the project site.

KK. The FPTU manufacturer provides the following:

1. Multi-point flow averaging sensors in the primary air inlet and inlet to the fan.

2. 24 VAC transformer.

3. 24 VAC fan start/stop relay.

4. 24 VAC relays for electric heating coil control through the BMS.

5. Manual fan speed adjustment or auto fan speed controller for DDC control of fan.

6. Sheet metal enclosure for UC.

7. Primary air damper and actuator.

LL. The FPTU manufacturer shall verify with the potential BMS contractors that:

1. The pressure differential generated by the multipoint sensors is compatible with the instrumentation to be provided by the BMS contractor.

2. The damper actuator is compatible with the output of the FPTU unit controller.

3. The 24 volt AC power supply is adequate for the satisfactory operation of the control system.

4. The 24 volt AC heater and fan control relays are compatible with the FPTU unit controller.

MM. All fan powered terminal units shall be identified on the bottom of the unit (minimum ½" high letters) and on the shipping carton with the floor and box number that identifies it along with the CFM settings. Every unit shall have a unique number combination that matches numbers on the contractor's coordination drawings as to its location and capacity and is coordinated with the DDC controller.

NN. The BMS contractor shall provide the terminal unit manufacturer with point to point wiring diagrams detailing the wiring of the DDC controller and other control equipment installed on the terminal device. The terminal unit manufacturer shall review and approve the wiring diagrams and coordinate any changes necessary with the control contractor. The terminal unit manufacturer shall incorporate the final version of the wiring diagram in his terminal unit submittals along with a letter from the BMS contractor stating his approval of the diagram. When the terminal units are released for fabrication and shipment, the BMS contractor shall be provided with a shipping schedule and terminal unit manufacturer's factory order numbers along with requirements for tagging of shipments. Controls for each and every release must be at the terminal unit manufacturer's facilities four weeks prior to scheduled shipments.

OO. These Specifications set forth the minimum requirements for VAV fan powered terminal devices. If it complies with these Specifications, VAV fan powered terminal devices manufactured by one of the following manufacturers will be acceptable: Nailor, Carrier, Trane or Titus.

2.3 TERMINAL UNITS - SINGLE DUCT CONSTANT VOLUME

A. Provide single duct constant volume terminal units in locations shown on the plans. Capacities and performance shall be as indicated on the schedule and are based upon Nailor Industries type 3000 or equal as approved.

B. Sizes, capacities, and performance are based upon units as manufactured by Nailor Industries. Units as manufactured by other manufacturers shall be considered as equal, if they meet performance specifications. Any substituted product shall, in all aspects, conform to the engineered sound and pressure drops specified.

C. The units shall be pressure independent and shall maintain to any CFM setting within +/- 5% regardless of changes in upstream static pressure.

D. At an inlet velocity of 2000 FPM, the maximum static pressure drop shall not exceed 0.25” w.g. for the basic unit or 0.35” with attenuator added.

E. The units shall be designed, installed and field adjusted, if necessary, to maintain controlled pressure independent air flow.

F. Features to accommodate field calibration and readjustment of air volume settings shall include gauge taps for balancing with a standard pressure gauge and adjustable flow settings at the controller.

G. Unit casing shall be 22 ga. Galvanized steel with round or flat oval inlets meeting SMACNA and ASHRAE standards. Outlets shall be rectangular with slip and drive connections. Valve assemblies of 16 ga. Steel are to have opposed blade dampers to reduce air turbulence and fitted with special seals for tight closure and minimized sound generation. In the fully closed position, air leakage past the closed damper shall not exceed 3% of the nominal catalog rating at 3” inlet static pressure, as rated by the Air Diffusion Council test procedure.

H. All units shall be lined with 1”, 1-1/2 lb. density fiberglass insulation. Edges are sealed against air flow erosion. Materials are to be in accordance with NFPA - 90A and UL 181 standards.

I. All insulation/sound absorbing material shall be protected by means of 24 gauge galvanized perforated steel panels to retain the insulation.

J. Where indicated , provide hot water reheat coils of capacities on the terminal unit schedule. Heating coils shall be furnished as part of the terminal unit. Water control valve shall be furnished by the automatic control contractor and field installed by the mechanical contractor.

K. Where indicated on the drawings the contractor, not the box manufacturer, shall furnish hot water reheat coils of capacities as indicated in the schedules. Coils shall be installed in the terminal unit discharge duct as shown. Water control valve shall be furnished by the automatic control contractor and field installed by the mechanical contractor. Box manufacturer shall provide access door upstream of reheat coil for ease of cleaning.

L. Terminal Unit Hot Water Heating Coils:

1. Hot water heater coils shall be integral to the unit, not an add on.

2. The heating coils shall be constructed and installed in accordance with the requirements of the local Authorities and shall be ETL listed as component of Box

3. The heating coils shall be fabricated from round seamless copper tubes rolled into headers to form a permanent pressure tight joint. Coils are to be self-venting type. A vent connection is to be provided in the supply header and a drain connection in the return header. Coil Finned tube shall be fabricated to permit expansion without transmitting stresses to casing. Provide even distribution of water to each tube.

4. Headers: constructed of close-grained gray cast iron, heavy wall copper, having pipe threads for supply and return connections.

5. Tubes: seamless deoxidized copper, 5/8" O.D. and 0.020" minimum wall thickness.

6. Fittings: return bends and expansion bends to be fabricated from 5/8" O.D. or 1" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to or greater than the tube wall thickness.

7. Fins: aluminum or copper plate type or helically wound on the tubes. The plate type fins shall be continuous across entire coil width. Provide efficient bond between fin and tube, making each fin perform as an integral part of the tube.

8. The coils are to be designed, tested and guaranteed for operation with steam or water pressure and temperature as per system pressures for valves and fittings.

9. Coil Performance: All data pertaining to coil performance are shown on drawings. Pipe all coils counterflow. All water coils to have not more than 6 feet/second water velocity and not more than 10 fins per inch.

10. Heating coils shall be provided with automatic control valves and shall be designed for operation with the DDC controller and control system as specified in the BMS section.

11. Shop Drawings shall be submitted for review as specified. These Shop Drawings shall indicate specifically the exact construction, materials, etc., of the heating coils to be furnished under these Specifications.

2.4 SINGLE DUCT VARIABLE AIR VOLUME UNITS (ELECTRIC ACTUATOR)

A. Provide single duct variable volume terminal units in locations shown on the plans. Capacities and performance shall be as indicated on the schedule and are based upon Nailor Industries type 3000 or equal as approved. All units shall be capable of shutoff features without additional control components or piping.

B. Sizes, capacities, and performance are based upon units as manufactured by Nailor Industries. Units as manufactured by other manufacturers shall be considered as equal, if they meet performance specifications. Any substituted product shall, in all aspects, conform to the engineered sound and pressure drops specified.

C. The units shall be pressure independent and shall reset CFM air volume within +/- 5% of required air flow, as determined by the space thermostat, regardless of changes in system air pressure. Devices utilizing CFM limiters will not be acceptable. The terminal air valve shall normally open on loss of electrical power. The minimum setting shall be 20% of peak flow.

D. The internal resistance of the terminal shall not exceed 0.4 inch w.g. for all sizes when handling maximum air volume shown on schedules.

E. A Diamond-Flow sensor shall be incorporated within the terminal. Differential pressure taps (separate from the control pressure taps) shall be provided for air flow measurement with a 0-1 inch gauge. Each terminal shall have a flow chart attached.

F. The units shall be designed, installed and field adjusted, if necessary, to maintain controlled pressure independent air flow.

G. Features to accommodate field calibration and readjustment of air volume settings shall include gauge taps for balancing with a standard pressure gauge and adjustable flow settings at the controller.

H. Unit casing shall be 22 ga. Galvanized steel with round or flat oval inlets meeting SMACNA or ASHRAE standards. Outlets shall be rectangular with slip and drive connections. Valve assemblies of 16 ga. Steel are to have opposed blade dampers to reduce air turbulence and fitted with special seals for tight closure and minimized sound generation. In the fully closed position, air leakage past the closed damper shall not exceed 3% of the nominal catalog rating at 3” inlet static pressure, as rated by the Air Diffusion Council test procedure.

I. All units are lined with 3/4”, 1-1/2 lb. density fiberglass insulation. Edges are sealed against air flow erosion. Materials are to be in accordance with NFPA - 90A and 90B and UL 181 standards.

J. All insulation/sound absorbing material shall be protected by means of 24 gauge galvanized perforated steel panels to retain the insulation.

K. The acoustical performance of the variable volume unit shall be tested in accordance with ADC Test Code 1062R4 standards, in an ADC, or independent approved laboratory. The manufacturer shall submit guaranteed sound power levels by octave bands. The sound power level shall be based on 10-13 watts. The octave band analysis shall be shown for .75", 1-1/2" and 3" S.P. differential across the terminal unit. Neither the manufacturer nor the specific unit selection will be approved until such ratings have been submitted.

The sound power level data submitted shall substantiate that the equipment types and sizes operating, as in an installed condition per plans and specifications, shall conform with data scheduled.

L. Prior to the approval of variable air volume boxes, the manufacturer shall demonstrate to the Owner and/or his representatives, the operation of a typical unit. This demonstration shall be conducted over the full operational range. If the unit so demonstrated is acceptable, the manufacturer shall make and submit an octave band analysis of this unit over the full operational range in an acoustical laboratory reverberant chamber. All similar production units shall have acoustical characteristics within plus or minus 2 db of the unit demonstrated, when operated under the same design conditions in the same test facility.

M. The manufacturer shall submit the following information determined in a reverberant chamber subsequent to the demonstration of the unit in the typical space for both discharge and radiated sound:

1. Sound power data by octave bands.

2. A description of the technique and apparatus used to determine sound power.

3. The test chamber room constants by octave bands.

4. The technique and apparatus used to determine the room constant.

5. Complete operating conditions at the time of testing, including room temperature, air temperature, static pressures, etc.

N. The BMS contractor shall furnish and ship the DDC controller and actuator to the VAV terminal unit manufacturer for installation at the factory. The BMS contractor shall supply written instructions and drawings containing sufficient information to enable the VAV unit manufacturer to undertake the installation satisfactorily.

O. The BMS contractor shall also furnish and ship all electronic room type thermostat (one stat per VAV terminal box) with locked cover.

P. Terminal box manufacturer shall provide for each unit proportional control electric actuator and electronic room type thermostat (one stat per VAV terminal) with locked cover. Actuators shall be factory mounted and linked. The controls shall have capability of field adjustment of maximum and minimum cfm quantities. There shall be separate adjustments for maximum and minimum cfm. Each unit shall include a warm-up sensor factory set at 75%F (adjustable setting from 70%F to 85%F) to provide morning warm-up features. The HVAC Contractor shall include the cost of mounting thermostats and wiring between terminals and thermostats.

Q. The electronic room thermostat and actuator (one (1) each per box) shall control the VAV as follows:

1. Room thermostat on a call for less cooling shall modulate the air flow from 100% cfm to 25% cfm. On a call for cooling, reverse sequence shall occur.

R. The VAV terminal box manufacturer shall provide a 24 VAC transformer, flow sensor, electric heat SCR controller, and controls enclosure. The VAV box manufacturer shall install and connect all controls in the factory.

S. Box manufacturer shall provide field calibration and check-out of all control components and shall furnish wiring diagrams and provide one years free service on the box and control components.

T. Where indicated provide hot water reheat coils of capacities on the terminal unit schedule. Heating coils shall be furnished as part of the terminal unit. Water control valve shall be furnished by the automatic control contractor and field installed by the mechanical contractor.

U. Where indicated on the drawings the contractor, not the box manufacturer, shall furnish hot water reheat coils of capacities as indicated in the schedules. Coils shall be installed in the terminal unit discharge duct as shown. Water control valve shall be furnished by the automatic control contractor and field installed by the mechanical contractor. Box manufacturer shall provide access door upstream of reheat coil for ease of cleaning.

V. Terminal Unit Hot Water Heating Coils:

1. Hot water heater coils shall be integral to the unit, not an add on.

2. The heating coils shall be constructed and installed in accordance with the requirements of the local Authorities and shall be ETL listed as component of Box

3. The heating coils shall be fabricated from round seamless copper tubes rolled into headers to form a permanent pressure tight joint. Coils are to be self-venting type. A vent connection is to be provided in the supply header and a drain connection in the return header. Coil Finned tube shall be fabricated to permit expansion without transmitting stresses to casing. Provide even distribution of water to each tube.

4. Headers: constructed of close-grained gray cast iron, heavy wall copper, having pipe threads for supply and return connections.

5. Tubes: seamless deoxidized copper, 5/8" O.D. and 0.020" minimum wall thickness.

6. Fittings: return bends and expansion bends to be fabricated from 5/8" O.D. or 1" O.D. seamless deoxidized copper tubing. Wall thickness, after forming, must be equal to or greater than the tube wall thickness.

7. Fins: aluminum or copper plate type or helically wound on the tubes. The plate type fins shall be continuous across entire coil width. Provide efficient bond between fin and tube, making each fin perform as an integral part of the tube.

8. The coils are to be designed, tested and guaranteed for operation with steam or water pressure and temperature as per system pressures for valves and fittings.

9. Coil Performance: all data pertaining to coil performance are shown on drawings. Pipe all coils counterflow. All water coils to have not more than 6 feet/second water velocity and not more than 10 fins per inch.

10. Heating coils shall be provided with automatic control valves and shall be designed for operation with the DDC controller and control system as specified in the BMS section.

11. Shop Drawings shall be submitted for review as specified. These Shop Drawings shall indicate specifically the exact construction, materials, etc., of the heating coils to be furnished under these Specifications.

2.5 FANS - GENERAL

A. General: Fan performance shall be based on tests conducted in accordance with AMCA Standard Test Code for Centrifugal and Axial Fans and fans shall bear the AMCA Certified Ratings Seal for Sound and Air Performance. Centrifugal fans to be non-over-loading having a sharply rising pressure characteristic which will extend throughout the operating range and continue to rise well beyond the efficiency peak to insure quiet, stable operation under all conditions. The horsepower characteristic shall be truly self-limiting and shall reach a peak in the normal selection area. Unit shall be of manufacture as noted on drawings, or approved. Submit sound power ratings for approval.

B. Fan shall be listed by Underwriters Laboratories (UL/cUL 705) for US and Canada. For restaurant applications, fan shall be listed by Underwriters Laboratories (UL/cUL 762) for US and Canada. For smoke control applications, fan shall be listed by Underwriters Laboratories (Power Ventilator for Smoke Control Systems) for US and Canada.

C. Fans shall be furnished to meet the performance requirements as set forth in the schedules and as specified herein.

D. Fans shall be provided with mechanical brake, coordinate with BMS.

E. Conditions for Approval

1. Submission for approval must show air flow, static pressure, brake horsepower, KW input sound power ratings and full load efficiency complying with motor efficiency as specified under another section of this work.

2. Fans to be selected at or near efficiency peak (submit fan curves).

3. Any corrective measures necessary to meet the damper performance requirements shall be the responsibility of the fan manufacturer, at no cost to the Owner.

F. Fans shall be statically and dynamically balanced at the factory prior to shipment. Fans shall be balanced for inverter duty operation (VFC). The fan will be balanced over the entire range of fan operation (30% to 100% of RPM). Filter-in measurements shall not exceed 5 mils in the horizontal and vertical planes. Filter-

out measurements shall not exceed 7.5 mils in the horizontal, vertical and axial planes.

G. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Greenheck.
2. Twin City
3. Loren Cook

2.6 CENTRIFUGAL FANS

A. Housing: The entire fan housing shall have continuously welded seams for leak proof operation and shall have a minimum 1 ½" outlet discharge flange. A performance cut-off shall be furnished to prevent the recirculation of air in the fan housing. Braced to prevent vibration or pulsation. Inlet to be fully streamlined.

B. Wheel and Blades: Air foil backward curved blades, to be continuously welded to both backplate and sideplate and seam welded along the back edge of the blade. Air passage to be free of interference (no intermediate rings or sway bracing) Wheels shall be statically and dynamically balanced before shipment. For construction use high strength alloy steel, treated for corrosion resistance (spark resistance, if required) or aluminum. Wheels shall be statically and dynamically balanced in accordance with AMCA Standard 204-96 "Balance Quality and Vibration Levels for Fans. High pressure air handling units shall only be furnished with Class III air foil fan wheels.

C. Finish: Interior and exterior of fan to be factory coated; manufacturer's standard rust resistant paint acceptable.

Standard finish shall a baked industrial grade finish conforming to the following ASTM Standards.

Final coating thickness is 1.5 - 2.5 mils.

Property	Test Method	Value
Salt Spray	ASTM B117	1000+ hours
Humidity Resistance	ASTM D2247	1000+ hours
Impact Resistance	ASTM D2794	100 in. lbs.
Pencil Hardness	ASTM D3363	2H
Crosshatch Adhesion	ASTM D3359-B	100%
Max Service Temperature		230 deg F

D. Shaft: Properly sized, one piece solid, hot rolled steel, accurately turned, ground and polished. Fan shafts shall not pass through their first critical speed as rated rpm is reached. Rust preventive coating to be provided. Fan wheels to be secured with slotted keyways on solid shafts and with taper lock hubs on tubular steel shafts.

E. Bearings: Heavy duty, self aligning pillow block, garage lubricated, anti-friction ball or roller type bearings selected for a minimum average life (AFBMA L-50) in excess of 200,000 hours operation at maximum cataloged operating conditions. Above 27" diameter fan wheel use horizontally split pillow block type bearings with tapered, double spherical rollers selected for a minimum average life (AFBMA L-50) in excess of 400,000 hours operation at maximum cataloged operating conditions.

Provide extended fittings to be mounted externally.

F. Inlet Screens: Required for all fans, constructed for easy removal, of heavy wire mesh.

G. Drain Connections: Provide 1" drain connection at bottom of fan.

H. Access Doors: Are required in all fan scrolls of fans over 36" wheel diameter of the quick opening type, secured to the frame by hand grip bolts and provided with lift handles. Raised type access doors shall be provided on all insulated fans (inner surface to be flush with the scroll).

I. Adjustable Inlet Vanes: To be provided for automatic operation for all variable air volume systems on supply and return fans. Vanes on DWDI fans shall be interconnected through a linkage that will allow vanes to operate in unison. Note that B.H.P. is 15% higher, and R.P.M. 5% higher than scheduled.

J. V-Belt Drives: The fans are to be driven with V-belt drive, of ample capacity sized for 1.5 x motor HP. Sheaves shall be adjustable ratio type; they shall be sized to give the required fan speed with motor sheave at about the middle of its range of adjustment. There shall be at least two (2) belts; and drive capable of carrying the entire load with an additional 50% safety factor. Belt guards with opening for RPM readings to be provided for all sheaves and belts. Submit drive data for approval. For fans with motors 75 HP and over, supply fixed ratio sheaves and manually adjustable inlet vanes in lieu of variable type sheaves. Performance (RPM, BHP) shall be corrected for inlet vane losses and fan RPM shall be selected 10% above specified fan operating point. Manufacturer shall guarantee that fan will operate stably when vanes operate 20% below fixed sheave RPM.

K. Provide belt guard, with access opening for RPM readings. Belt guard to meet OSHA requirements.

L. Vibration Isolation: Vibration isolators shall be provided as specified elsewhere.

M. In cases of fans where more than one speed is specified isolators shall be selected for the lowest speed.

N. The motor and fan base shall be welded or bolted to form a common base to prevent any uncommon physical motion of the fan and motor.

O. Electric Motors: Each fan shall be provided with an electrical motor and motor control as specified elsewhere.

P. Replacement of Sheaves: Provide additional adjustable or fixed sheaves at no extra cost, if required for balancing.

Q. Where adjustable inlet vanes are specified, the fan manufacturer shall submit fan curves corrected for inlet vanes l00% open. Fans with inlet vanes wide open shall have a rating of not less than 99% of catalogued rating without inlet vanes.

R. All fans that are field assembled, or are 100 hp or over, shall require the services of a factory engineer to balance and check bearings, pulleys, belts, etc. A report shall be filed attesting to the readiness of the fan to run and that the bearings are properly lubricated. He shall sign the lubrication tag which shall be turned over to the building maintenance personnel.

S. Scroll bypass dampers: Where called for on the plans, provide opposed airfoil blade damper section factory mounted in the fan scroll. Provide control arm suitable for automatic operation. Dampers shall bypass air when minimum modulation point of inlet vane operation has been reached to extend modulation range. As indicated on the schedule, where such dampers are not available from the manufacturer, contractor must provide dampers in the ductwork capable of bypassing at least 50% of the design air quantity back to the inlet or inlets of the fan.

T. Tubular centrifugal fans shall be similar in all requests to the previous description. Housings shall be tubular type to provide straight through inline air flow entrance to discharge Multiple aerodynamic conversion vanes shall be located immediately following the wheel to redirect the air flow in order to minimize noise. Inlet and outlet diameters shall be identical to accommodate a single duct size. All horizontal fans shall be V-belt driven, arrangement 9 with motor mounted on an integral vibration base. All vertical fans shall be V-belt driven, arrangement 9, with shaft and bearings designed to withstand the vertical thrust load, and with motor mounted on an adjustable platform welded securely to the tubular housing. Fan manufacturer shall instruct this trade in procedures to be followed during storage and prestart up (layup) periods such as hand rotation every 30 days to prevent bearing flat spots. He shall through his factory representative perform pre-start up inspection for lubrication and proper access for maintenance. Signed records shall be submitted as part of the operating instructions.

2.7 FANS (PLUG FANS)

A. General: Plug Fans shall be of the belt driven centrifugal type as specified. Fan shall be constructed of heavy gauge steel with bearing support members positioned to directly oppose belt tension. Mounting panel shall have formed flange with welded corners on all four sides to insure flatness and rigidity and shall have pre-punched mounting holes for vertical or horizontal installation. The plenum fans shall be enclosed in an OSHA safety screened cage.

B. Fan shall include mounting panel, wheel, fan shaft, bearings and structural support members as a factory assembled unit. All steel and sheet metal parts shall be thoroughly cleaned, conditioned, and painted with enamel primer and enamel top coat prior to final assembly.

C. Finish: Interior and exterior of fan to be factory coated:

Standard finish shall a baked industrial grade finish conforming to the following ASTM Standards.

Final coating thickness is 1.5 - 2.5 mils.

Property	Test Method	Value
Salt Spray	ASTM B117	1000+ hours
Humidity Resistance	ASTM D2247	1000+ hours
Impact Resistance	ASTM D2794	100 in. lbs.
Pencil Hardness	ASTM D3363	2H
Crosshatch Adhesion A	STM D3359-B	100%
Max Service Temperature		230 deg F

D. Plug fans shall have a non-overloading steel **[airfoil]** or **[backward inclined]** wheel as specified. Blades on all sizes and classes shall be securely welded to both a deep spun inlet shroud and a heavy backplate.

E. Fans to be non-overloading having a sharply rising pressure characteristic which will extend throughout the operating range and continue to rise well beyond the efficiency peak to insure quiet, stable operation under all conditions. The horsepower characteristic shall be truly self-limiting and shall reach a peak in the normal selection area.

F. Fan shaft to be properly sized and protectively coated with lubricating oil. Fan shafts shall be solid of tubular steel and properly designed so than fan shaft does not pass through first critical speed as unit comes up to rated RPM. Fan wheels to be secured with slotted keyways on solid shafts and with taper lock hubs on tubular steel shafts to prevent slipping. Rust preventive coating to be provided.

G. Fans shall be statically and dynamically tested and balanced , in the factory, as an assembly at the required RPM to meet the design specifications. Key fan wheels to fan shaft to prevent slipping. Wheels shall be statically and dynamically balanced in accordance with AMCA Standard 204-96 "Balance Quality and Vibration Levels for Fans.

H. After the pre-balanced fan is installed in the air handler, the entire fan section shall be run-balanced at the speed to insure smooth and trouble-free operation. Fans with variable frequency drives shall be balanced for inventer duty operation. The fan will be balanced over the entire range of fan operation (30% to 100% of RPM). Filter-in measurements shall not exceed 5 mils in the horizontal and vertical planes. Filter-out measurements shall not exceed 7.5 mils in the horizontal, vertical and axial planes.

I. The fan shall have heavy gauge spun aluminum inlet cone carefully matched to the e wheel shroud to provide smooth airflow and quiet, efficient operation.

J. Provide a velocity pressure converter cone at the discharge of the fan. The cone shall be constructed of # 20 gauge galvanized sheet steel with ½” diameter holes on 15/16” staggered centers. Configuration shall be of the pyramid or cone trustrom design reinforced and shall have a free area of not less than 150% of the fan discharge area.

K. Bearings - Self-aligning, grease lubricated, ball type. Internal bearings, where used, shall be provided with extended fittings mounted externally at drive side of unit. Minimum 400,000 hours average life, as defined by AFBMA.

L. Drive - Adjustable, minimum of two grooves furnished on all motor sizes. Drive sized for 1.5 x motor H.P. Belt guard to meet OSHA requirements and to have access opening for RPM readings. Provide belt guard (whether motor is inside or outside unit).

M. Fan and fan motor shall be internally mounted and isolated on a full width isolator support bases as specified under another Section. The motor and fan base shall be welded or bolted to form a common base to prevent any uncommon physical motion of the fan and motor.

N. Install flexible canvas ducts between fan and casings to ensure complete isolation. Flexible canvas ducts shall comply with NFPA 90A.

O. The entire unit shall be externally isolated from the supply duct work and piping by contractor in order to avoid transmission of noise and vibration through the ductwork.

P. Electric Motors: Each fan shall be provided with an electrical motor and motor control as specified elsewhere.

Q. Inlet Screens: Required for all fans, constructed for easy removal, of heavy wire mesh.

R. Drain Connections: Provide 1" drain connection.

S. Replacement of Sheaves: Provide additional adjustable or fixed sheaves at no extra cost, as required for balancing.

2.8 ROOF EXHAUST FANS (LOW SILHOUETTE)

A. Roof fans shall be low contour Type P.C., as scheduled on drawings or approved equal.

B. Housings shall be of aluminum, rigidly braced with heavy angle iron frame securely fastened to fan base with stainless steel bolts.

C. Fan wheels shall be of the backwardly inclined centrifugal type, all welded construction, having blades of not less than No. 12 gauge and wheel plates of not less than No. 10 gauge.

D. Fans shall have variable speed pulleys. Fans shall have prewired safety disconnect switch with thermal overload protection mounted adjacent to fan motor.

E. Automatic louvres shall be mounted in curb below the fan. Provide a P.V.C. bird screen.

F. Furnish and install Sound Curbs of aluminum construction, all continuous heliarc welded, of 0.064 minimum gauge. All surfaces inside sound curb to be lined with minimum of 2" sound absorbing insulation. Sound curbs to be set on concrete curbs by others, and to have bases sized to fit the outside dimensions of the concrete curbs, which may be specially sized to follow duct or shaft requirements.

G. Pressure drop through sound curb is not to exceed 1/8" S.P. Total sound power reduction to be a minimum of 90%. When used in New York City apartment buildings, sound pressure levels at the registers to comply with Building Code requirements, as per item C26.1208.3(d).

H. Self-acting backdraft dampers shall be connected to bottom of sound curbs, and sound curbs to have access panels for damper access. Overall height of sound curb, including damper access panel, to be 24". Sound curb to be model ATE-NYC as manufactured by Greenheck Fan & Ventilator Corporation.

I. Furnish and install Sound Curbs of aluminum construction, all continuous heliarc welded, of 0.64 minimum gauge. All surfaces inside sound cupb to be lined with minimum 2" sound absorbing insulation. Sound curbs to be set on concrete curbs by others, and to have bases sized to fit the outside dimensions of the concrete curbs, which may be specially sized to follow duct or shaft requirements. Pressure drop through sound curb is not to exceed 1/8" S.P. Total sound power reduction to be a minimum of 90%. Self-acting backdraft dampers shall be connected to bottom of sound curbs, and sound curbs to have access panels for damper access. Sound curb to be model AT as manufactured by Greenheck Fan & Ventilator Corporation or equal.

2.9 ROOF EXHAUST FANS

A. Roof fans shall be standard centrifugal roof exhausters as scheduled on drawings or approved equal.

B. Housings shall be of aluminum, rigidly braced with heavy angle iron frame and beaded for additional strength.

C. Fan motor, drive and bearings shall be mounted above the fan wheel in a compartment isolating these components from the air handled by the fan.

D. Fan shall have a weather-proof hood hinged to the fan frame, with stainless steel lockable hasp, providing easy and ready access to the fan components.

E. Fan wheels shall be of the backwardly inclined centrifugal type, all welded construction, having blades of not less than No. 12 gauge and wheel plates of not less than No. 10 gauge.

F. Fans shall have variable speed pulleys. Fans shall have prewired safety disconnect switch with thermal overload protection mounted adjacent to motor.

G. Automatic louvres shall be mounted in curb below fan. Provide a P.V.C. bird screen.

H. Self-acting backdraft dampers shall be connected to bottom of sound curbs, and sound curbs to have access panels for damper access. Overall height of sound curb, including damper access panel, to be 24". Sound curb to be model ATE-NYC as manufactured by Greenheck Fan & Ventilator Corporation.

2.10 FAN-COIL UNITS

A. Fan-coil air conditioning units are as shown and scheduled on the plans. The units shall be Trane or approved equal. Unit shall be provided prewired ready for one wiring connection by the Electrical Trade.

B. Submit samples of units typical for this if requested.

C. Cabinet enclosures shall be included. Cabinet finish for fan-coil units shall comply with the Corp of Engineer 500 hours salt spray test specification, CE301.35 and CE301.37.

D. All models and sizes specified for this project shall be in accordance with ARI Industry Standard for Room Fan-Coil Air Conditioners, 441-66.

E. Manufacturer shall attest that units will pass an insulation efficiency test using ambient air of 80 degrees Fahrenheit dry bulb and 75 degrees Fahrenheit, water temperature rise of 8 degrees Fahrenheit. There shall be no condensate drip from the unit when the fans are off or at high speed for a full 8 hours.

F. Units to comply with National Electric Code.

G. Basic units heavy gauge galvanized steel, reinforced and welded. Interior parts exposed to moisture zinc-coated steel. Casing acoustically and thermally insulated with mat-faced glass fiber blanket material.

H. Coils with aluminum fins mechanically bonded to copper tubes. Return air connections fitted with a manual air vent. Coils suitable for a minimum of 250 PSIG working pressure. Connections female sweat.

I. Provide coils as indicated on plans.

J. Main coil and auxiliary drain pans with zinc-protected coating and insulated to prevent sweating. All end pocket piping, service and temperature control valves where applicable shall be insulated unless auxiliary drain pan fully extends under these units.

K. Fan wheels of the centrifugal forward-curved, double-width type.

L. Filter shall be concealed from sight on vertical units and removable without unlocking unit front panel. Horizontal cabinet models shall have hinged bottom panel for access. Filters shall be permanent filters of cleanable aluminum mesh type.

M. All motors shall have integral thermal overload protection. Motors shall be 3 speed tap wound permanent split capacitor. Shaded pole motors are not permitted. Motors & control circuits shall be 120 volt. (Provide a 277 volt/110 volt transformer for units with 277 volt electrical supply.)

N. Base unit cabinet enclosure to be provided with the inlet and outlet arrangement as shown on the plans. Enclosure shall have l6 gauge panels, acoustically and thermally insulated with ½" 1-1/2 pound density, mat-faced glass fiber where exposed to airstream. Provide removable metal discharge grille with discharge 15 from vertical. The cabinet shall be phosphatized and provided with baked enamel finish in one of the manufacturer's colors to be selected by Architect.

O. Provide 3 speed prewired fan switch, mounted in place, readily accessible through access door.

2.11 ROOF RELIEF VENTILATORS

A. Furnish and install as scheduled on plans.

B. Metal base and housing shall be aluminum.

C. Provide gravity actuated louvers.

D. Provide aluminum protective bird screen.

2.12 VERTICAL AND MISCELLANEOUS FAN COIL UNITS

A. General

1. Furnish and install vertical riser type fan coil units as scheduled and shown on the plans. Unit capacity ratings shall be certified in compliance with industry Standard 441-66 for Equipment, Testing and Rating of Fan Coil Air Conditioners as administered by ARI. The entire unit shall be Underwriters Laboratory listed, comply fully with the National Electric Code, and be in compliance with all applicable state and local codes.

2. The fan coil unit shall consist of a galvanized steel chassis, acoustic and thermal insulation, access panel, chilled water cooling coil, electric heating coil, fan, motor, drain pan, return air grille, discharge plenum, supply air grilles, riser piping, valves, expansion compensators, filter, controls and transformer.

3. Units shall be quiet in operation, not to exceed NC 35. Units shall be acoustically tested and rated in accordance with ARI Standard 443-70.

4. Units shall be as manufactured by Trane, or approved equal.

B. Casing

1. The unit shall be designed for furred-in installation. The unit casing shall be fabricated of minimum 20-gauge galvanized steel, thermally and acoustically insulated with ½-inch thick, 1-pound density, neoprene coated fiberglass.

2. Each unit shall be furnished with a rotatable discharge plenum having air discharge openings as shown on the plans. The fan coil unit manufacturer shall provide a single deflection discharge grille for air discharge opening. Grilles shall have adjustable extruded aluminum louvers with paintable baked aluminum finish.

3. The unit shall be furnished with an easily removable front panel which permits complete access to all internal unit components including filter, motor, fan, drain pan, coils, valves and wiring. The front panel shall include a stamped return air grille. Panel shall have a prime finish suitable for field painting under another trade.

4. The unit shall include a hinged control cover which shall conceal, yet give ready access to, the unit thermostat and control switches. The control cover shall have a prime finish suitable for field painting under another trade.

C. Filter

1. The unit shall be furnished with a 1-inch thick disposable fiberglass filter. The filter shall be concealed from sight, and mounted in a frame directly behind the air inlet grille on the front panel. The filter shall be quickly accessible by removing the unit front panel.

D. Fan and Motor Assembly

1. The unit shall incorporate a blow-through design. The fan and motor assembly shall be mounted integral to the unit drain pan in such a manner that the entire assembly (fan, motor, and drain pan) easily slides out of the unit on slide rail channels, allowing accessibility and ease of service of these components.

2. Fans shall be DWDI forward-curved centrifugal type, with wheels and housings fabricated from heavy gauge galvanized steel.

3. Drain pan shall be constructed of galvanized steel with self-extinguishing 3-pound cellular insulating liner. A 7/8 inch ID drain line shall connect the drain pan to the main drain riser of the unit.

4. The unit motor shall be three-speed, permanent split capacitor type, and shall not exceed 135 watts (400 CFM) and 100 Watts (300 CFM) at high speed. The motor shall operate on 115 volt, 60 cycle, 1 phase power. Where units are scheduled with electric heating coils which use other than 115 volt power, the fan coil unit shall include a factory mounted and wired transformer to convert the main unit power supply (as determined by the electrical characteristics) to 115 volts for the motor, control valve, and unit controls.

5. The unit fan motor shall have integral thermal overload protection with automatic reset. The motor shall be capable of starting at 78 percent of rated voltage, and operate satisfactorily at 90 percent of rated voltage at all speed settings, and at 10 percent overvoltage without undue magnetic noise. The motor winding temperature rise shall not exceed 50 C on high speed and 55 C on reduced speeds. Motors shall be resiliently mounted to prevent transmission of vibration, and shall include a quick disconnect plug for ease of removal. Motors shall be factory run and tested in the assembled fan coil unit prior to shipment.

E. Coils and Piping Packages

1. Unit chilled water cooling coil shall be constructed of 5/8 inch OD seamless copper tubes mechanically bonded to configurated plate type aluminum fins.

2. The fan coil unit shall include a factory installed piping package for the cooling coil consisting of a manual air vent, motorized two position electric control valve, Griswold flow control valve, globe stop valves on supply and return, multiple loop expansion compensator, and all interconnecting piping. The entire coil and piping package shall be factory tested and rated for 300 psig design working pressure.

3. The fan coil unit shall include a factory installed electric heating coil. Coil shall be of the open grid electric resistance type of the capacities indicated on the schedules. Coil shall include factory installed contactors and high limit controls. Coil shall be factory wired to the fan coil unit junction box. A factory installed and wired two-pole unit disconnect switch with NEMA Type I enclosure shall be provided. Coil voltage shall be 277 volt.

F. Risers

1. Fan coil units shall be provided with factory installed risers of the sizes indicated on the drawings. Risers shall be attached to the unit with floating bracket assemblies which allow riser expansion and contraction while assuring consistent riser-to-riser alignment.

2. Supply and return risers and 1-1/4" drain riser shall be type M copper, insulated with ½ inch fiberglass thermal insulation. Armaflex is not permitted. PVC is not permitted.

G. Temperature and Controls

1. Fan coil unit shall include factory installed and wired room temperature controls, unit mounted and readily accessible at the front of the unit. A rotary type fan motor controller shall permit manual selection of the fan speed at "OFF-HIGH-MEDIUM-LOW". A thermostat, manually adjustable, shall control the cooling control valve or the electric heating coil as required to maintain the desired room conditions.

H. Provide low limit (55°F) stat to override off position for night heating.

PART 3 - INSTALLATION

3.1 PREPARATION

A. Cleanliness of sheet metal.

3.2 INSPECTION

A. Examine areas and conditions under which air distribution devices are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected.

3.3 INSTALLATION

A. General: Install air devices in accordance with manufacturer's written instructions and in accordance with recognized industry practices to insure that products serve intended function.

B. Coordinate with other work, including ductwork and duct accessories, as necessary to interface installation of air devices with other work.

C. This contractor shall be fully responsible for coordinating the electrical power feed arrangements (voltage/phase/amperage) for all devices requiring same, as indicated on the electrical contract documents. In the event that the devices delivered to the site do not comply with the electrical feed arrangements, he shall be fully responsible for all costs incurred to remediate the situation.

D. All required supports, hangers, anchors, and guides shall be provided and installed by this contractor. Shop drawings shall be submitted indicating the following.

1. All ductwork; flues, register boxes, air chambers, dampers, and all auxiliary work of any kind, necessary to make the various air conditioning, ventilating and heating systems of the building complete and ready for operation, shall be furnished and installed.

2. The specifications refer to SMACNA standards, which shall be considered minimal. If local codes require other standards than described in SMACNA, local codes shall govern.

3. All ductwork and distribution devices indicated on drawings is schematic. Therefore, changes in duct size and/or location shall be made where necessary to conform to space conditions, without additional cost to the Owner.

4. Dimensions given on drawings of all acoustically lined ducts shall be the clear inside dimension. Refer to "Acoustical Treatment".

5. Furnish and install manual dampers, fire dampers, registers, grilles, register boxes, access doors, sound traps, etc., as described herein and elsewhere in the specifications and as required for a complete system, ready for operation.

6. Exact dimensions of register boxes must await approval of grilles, and exact locations shall be submitted for approval, otherwise any changes directed after installation shall be made without additional cost. All register boxes and other opening of the ductwork must be kept tightly closed during construction to keep out rubbish.

END OF SECTION 15882

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15886 - DAMPERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section includes following:
1. Dampers.
2. Damper Terminal Strips.
3. Purge Dampers.
4. Dampers for Balancing.
5. Pressure Sensitive.
6. Dampers for Fire Protection.
7. Fusible Link Dampers.
8. Smoke Dampers.
9. Refer to other Division 15 sections for air distribution devices and accessories required in conjunction with this work.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: The following sections contain requirements that relate to this section:
1. Section 15010 - Basic Mechanical Requirements.
2. Section 15050 - Basic Mechanical Materials and Methods.
3. Section 15250 - Mechanical Insulation.
4. Section 15880 - Metal Ductwork
5. Section 15882 - Air Distribution Devices.
6. Section 15950 - Building Management and Controls.
7. This section is a part of each Division 15000 Section.
8. Division 16 - Electrical.

1.3 REFERENCES

A. SMACNA.

B. ASHRAE.

C. NFPA.

1.4 QUALITY ASSURANCE

A. Qualify welding processes and welding operators in accordance with AWS.D1.1 “Structural Welding Code - Steel” for hangers and supports and SWS.D9.1 “Sheet Metal Welding Code.”

B. Qualify each welder in accordance with AWS qualification tests for welding processes involved. Certify that their qualification is current.

C. NFPA Compliance: Comply with the following NFPA Standards:

1. NFPA 90A, “Standard for the Installation of Air Conditioning and Ventilating Systems,” except as indicated otherwise.

2. NFPA 96, “Standard for the Installation of Equipment for the Removal of Smoke and Grease-Laden Vapors for Commercial Cooking Equipment,” Chapter 3, “Duct System,” for kitchen hood duct systems, except as indicated otherwise.

D. SMACNA - HVAC Duct Construction Standards, Latest Edition.

E. The contractor must comply with the specification in its entirety.

F. At the discretion of the Owner, sheet metal gauges, reinforcing and dampers may be checked at various times to verify all duct construction is in compliance. If on inspections, changes have been made without prior approval, the contractor will make the applicable changes to comply with this specification, at the contractor’s expense.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials for each service, and locations.

C. Product data including details of construction relative to materials, performance data (including pressure drops), dimensions of individual components and profiles for the following items:

1. Dampers.
2. Indicate the location and rating of all dampers on shop drawings and submittals.

3. Include damper manufacturer's installation instructions as part of the damper submittal. These instructions shall describe the applicable requirements for damper sleeve thickness; retaining angles; sealing; duct-to sleeve connections; preparation of wall, floor or ceiling openings; and other requirements to provide an installation equivalent to that tested by the damper manufacturer during the UL 555, UL 555S and UL 555C qualification procedures. Detail any proposed installations that deviate from these manufacturer's instructions and explain the needed deviations. Fire and smoke damper installations shall comply with the manufacturer's instructions. Any submitted deviations must be approved by the appropriate authority having jurisdiction.

D. Welding certificates including welding procedures specifications, welding procedures qualifications test records, and welders qualifications test records complying with requirements specified in “Quality Assurance” above.

E. Maintenance data for dampers, fire dampers, and smoke dampers, in accordance with Division 15 Section “Basic Mechanical Requirements” and Division 1.

1.6 DEFINITIONS

A. Sealing Requirements Definitions: For the purposes of duct systems sealing requirements specified in this Section, the following definitions apply.

1. Seams: A seam is defined as jointing of two longitudinally (in the direction of airflow) oriented edges of duct surface material occurring between two joints. All other duct surface connections made on the perimeter are deemed to be joints.

2. Joints: Joints include girth joints, branch and subbranch intersections; so-called duct collar tap-ins; fitting subsections, louver and air terminal connection to ducts; access door and access panel frames and jambs; duct, plenum and casing abutments to building structures.

PART 2 - PRODUCTS

2.1 DAMPERS - GENERAL

A. All electric and/or pneumatic operated dampers which have a fire and/or smoke rating shall be furnished by the mechanical contractor. All other electric and/or pneumatic operated dampers shall be furnished by the Controls (ATC/BMS) Contractor. Fusible link dampers for fire protection, manual dampers for balancing and/or shut-off as well as dampers which are specified as part of factory built air handling units or terminal units shall be furnished by the mechanical contractor. All dampers shall be installed by the mechanical contractor.

B. Dampers of all ratings and types shall be of the nominal 100% face area type, with blade package and frame components out of the airstream. These dampers shall include the required oversize enclosures that shall be sealed by the damper manufacturer for the appropriate duct pressure class into which they are installed. Such dampers shall have appropriate rectangular, flat oval or round duct collars to facilitate connection of mating ductwork. The Contractor shall be responsible for any additional sealing of duct collars and connections required to maintain the duct seal class requirements, but shall not jeopardize the UL breakaway connection.

C. The mechanical contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The actuators shall be located outside of the airstream. The mechanical contractor shall provide a terminal strip alongside the damper for all dampers he furnishes.

D. The controls contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The actuators shall be located outside of the airstream. The controls contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

E. Wiring for motor operated dampers that have a fire and/or smoke rating shall be provided by the mechanical trade from the damper actuator and any associated end switches and sensors to a terminal strip that is wall mounted along side the damper.

F. The controls contractor shall provide wiring as follows:

1. Between the BMS and the terminal strip for all dampers monitored and/or controlled by the BMS whether or not the controls contractor has furnished the damper.

2. Between the terminal strip for all dampers and their associated thermostats, pressure switches, etc. whether or not the control contractor has furnished the damper.

G. Dampers incorporating multiple sections shall be controlled in unison. Where more than one (1) actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly.

H. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement.

I. The following table summarizes the trade responsibilities with respect to automatic dampers:

	NON-FIRE OR SMOKE RATED DAMPERS	FIRE AND/OR SMOKE RATED DAMPERS NOT CONTROLLED BY FIRE ALARM SYSTEM	FIRE AND/OR SMOKE RATED DAMPERS CONTROLLED BY FIRE ALARM SYSTEM
Furnish Damper	Controls Contr.	Mech. Trade	Mech Trade
Install Damper	Mech. Trade	Mech. Trade	Mech. Trade
Furnish Actuator(s)	Controls Contr.	Mech. Trade	Mech. Trade
Install Actuator(s)	Mech. Trade	Mech. Trade	Mech. Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contr.	Mech. Trade	Mech. Trade
Provide wiring between actuator, end switches, heat sensors, and terminal strip	Controls Contr.	Mech. Trade	Mech. Trade
Provide wiring from Central Control System (BMS) to damper terminal strip	Controls Contr.	Controls Contr.	Controls Contr.
Provide wiring from FAS to damper terminal strip			Electrical Trade
Furnish 120V main power to elect. actuators (See notes below)	Controls Contr.	Controls Contr.	Electrical Trade
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contr.	Controls Contr.	Controls Contr.
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contr.	Controls Contr.	Controls Contr.

NOTES

1. Controls contractor shall have overall responsibility for the complete coordination of the work and the operation of the damper/actuator installation.

2. In mechanical rooms 120V power circuits will be provided from an emergency appliance panel. These circuits will be terminated in a junction box located in each associated mechanical room and shall be used by the controls contractor to supply local control panels and critical equipment.

   These circuits will also be used by the electrical trade to supply dampers, etc. , requiring control by the Fire Alarm System. Final connection from the terminal strips to the actuators, end switches and sensors shall be by the mechanical trade.

3. For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from the motor starter control circuit. All wiring shall be by the controls contractor.

2.2 DAMPER TERMINAL STRIPS

A. Terminal strip(s) shall be provided along side all motorized dampers. If the damper has a smoke and/or fire rating, the terminal strip shall be provided by the Mechanical Trade. If the damper does not have a fire and/or smoke rating then the terminal strip shall be provided by the controls contractor.

B. Where dampers are furnished by the controls contractor then he shall provide relays, interconnect wiring and other components to meet the requirements detailed below. The terminal strip(s), relays, etc. shall be housed in wall mounted enclosures which meet the specifications detailed for local starter enclosures.

C. The terminal strip shall be wired such that the Central Control System (ATC/BMS) can undertake the following control and monitoring functions:

   1. Open Control - A pair of terminals shall be wired such that when a controls (ATC/BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. This signal from the Central Control System (ATC/BMS) shall be overridden by a close signal from the Fire Alarm System (FAS) Where dampers are interlocked to motors then the wiring shall be to these terminals.

   2. Close Control - A pair of terminals shall be wired such that when a controls (ATC/BMS) relay closes a contact pair across these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used. This signal from the Central Control System (ATC/BMS) shall be overridden by an open signal from the FAS.

   3. Motor Interlock - A pair of terminals shall be wired to an end switch on the actuator such that the contacts between the terminals shall be closed when the damper is fully open and open when the damper is not fully open. This pair of terminals shall be used for interlocking a damper with a motor such that the motor will not be able to start if the damper is not fully open.

2.3 PURGE DAMPERS

A. For each damper which is to be monitored and/or controlled by the Fire Alarm System (FAS), the damper actuator, heat sensor and end switches shall each be wired by the mechanical trade to a terminal strip(s) mounted adjacent to the damper so that the FAS can undertake the following control and monitoring functions:

1. FAS "Open/Close" Control - The damper will be driven open in response to closure of an FAS relay contact and will spring closed in response to opening of this relay contact.

2. FAS "Override Open" Control (Smoke Purge Dampers Only) - The damper will be re-opened, subsequent to a heat sensor initiated closure, in response to closure of a second FAS relay contact (or reclosure of the first contact for single sensor dampers).

3. FAS "Open/Closed" Status Monitoring Control (Smoke Purge Dampers Only) - End Switch closures will cause activation of FAS "opened" and "closed" relays in response to operation of end switches at both ends of travel.

4. FAS "Override of ATC (BMS)" Control - For each damper requiring both FAS and ATC (BMS) control, the Controls Contractor shall mount an interface relay within 30 circuiting feet of the damper terminal strip, so wired as to permit FAS override of the ATC (BMS) control.

B. The controls contractor's damper manufacturer shall provide all necessary wiring diagrams to the FAS contractors.

C. Dampers furnished by the mechanical trade shall have similar terminal strips to which the controls contractor shall wire where necessary.

2.4 DAMPERS FOR BALANCING

A. Provide manual dampers for balancing the air systems.

B. Construction shall conform to latest SMACNA standards. When installing dampers in ducts to be insulated provide raised bracket for damper quadrant with height equal to insulation thickness.

C. If location of balancing dampers is not defined on the drawings the following minimum standards shall govern:

1. All supply & return air main branches from trunk, and all sub branches from mains shall have balancing dampers.

2. Locate damper minimum 3' from air outlet and inlet to avoid noise transmission.

D. Coordinate with G.C. for easy access to damper.

E. For inaccessible ceilings, as well as for specialty areas such as lobbies, etc., furnish remote damper actuator operable through face of nearest diffuser. Damper controller and cable shall be concealed above the ceiling. Similar to Bowden remote cable control system with Young regulator damper controllers. Balancing dampers shall include all necessary hardware to ensure compatability with remote cable control system.

2.5 PRESSURE SENSITIVE BACKDRAFT DAMPER

A. Backdraft Dampers - Provide as sized in drawings. Based on Arrow Louver & Damper Model 366 Potteroff louver and damper models BD-64, BD-84, with adjustable counterbalance mounted internally on blades, or approved equal.

B. Frames - Extruded Aluminum 6063-T5 Alloy .081 B & S Ga., 1" x 4" x 1" Channel with gasketing on all four sides.

C. Blades - Extruded Aluminum 6063-T5 Alloy .081 B & S Ga. contoured for strength and overlap edges with gaskets to insure low leakage.

D. Shafts - ½" dia. Extruded Aluminum - Pinlock Design.

E. Seals - Extruded Interlocked Silicone Rubber Seals on blade edges and expanded polyurethane on frame.

F. Linkage - Cadmium plated steel mounted on blades.

G. Screen - ½" Aluminum Bird Screen in "U" frame to be removable on both sides of unit, as required.

H. Balances:

1. Removable fixed weights on blades and adjustable counterweights for finite adjustments in field by this trade.

2. Fixed weights and adjustable counterbalance weights shall be installed to resist opening. Fixed weights and adjustable counterbalance weights are to be able to be removed from upstream of damper. All weight, fixed and adjustable counterbalance, can be on the exterior of damper frame. Finite adjustments allowed in field by this trade.

I. Housing - 16 Ga. Galvanized Metal Sleeve.

J. Damper size is based on .15" s.p. drop at 400 ft./min. Damper shall maintain .15" s.p. in shaft.

2.6 DAMPERS FOR FIRE PROTECTION

A. Dampers and doors for fire protection shall be identified by the use of the symbol FLD on the drawings. Note that the use of the symbol FLD implies the provision of access doors. For installation in 1-1/2 Hr. or 2 Hr. fire separations or fire divisions provide 1-1/2 hour fusible link fire dampers U.L. labeled for use in Class B openings. For installation in 3 or 4 hour fire separations or fire divisions provide two fire dampers in series U.L. labeled for use in Class A openings, or other UL classified damper rated for 3 hrs.

B. Fire dampers in stainless steel duct systems shall be type 316 stainless steel.

2.7 FUSIBLE LINK DAMPERS (FLD)

A. Fusible Link Dampers and Fire Doors shall be installed where shown in the drawings and where required by code, and shall be of the folding blade type, Fire/Seal as manufactured by Air Balance, Inc., and shall bear the Underwriters' Laboratory label. Type “B” or “C” mountings shall be used for all installations, frames and blades are to be outside of airstream. Type "A" mountings are not permitted. Horizontally mounted dampers shall be operated by stainless steel negotiator springs with locking devices to insure positive closure. Fire damper shall meet the requirements of latest N.F.P.A. Bulletin #90A, and shall be tested in accordance with U.L. 555 test criteria for fire, corrosion and dust loading, labeled and listed by Underwriters' Laboratories. Dampers of other manufacturers may be approved subject to proper submission of Underwriters acceptance plus pressure drop calculations.

B. Local codes shall take precedence where they supercede NFPA. However, the Contractor shall notify the Engineer in writing citing such differences by reference to such codes should the contract documents not reflect these differences.

C. FLD's shall be provided as follows:

1. At each penetration of a vertical shaft. On upflow exhaust ducts where permitted by Code, a 22" long internal boot may be used after approval of duct pressure drop calculation.
2. At each fireproof slab penetration where there is no vertical fireproof shaft.
3. At each penetration of a required fire separation or fire division.
4. At each penetration of a required fire rated corridor or ceiling.

D. General:

1. Units shall be approved for use by the authorities having jurisdiction.
2. The Contractor shall clearly indicate location of units on shop drawings and shall provide access doors in the ducts at each damper of sufficient size and type to permit inspection and replacement of linkage. Provide itemized list of fire dampers for inspection and for posting in Engineers office. It shall be the Contractor's responsibility to coordinate all locations of duct access doors.
3. Access doors shall be cam latched with vinyl gasket to provide tightest possible seal between the duct and frame. Doors shall be self-tightening and gasketed with hand operated cam locks and will be fully insulated. Access doors shall be Air Balance, Inc. Fire/Seal or approved equal.
4. Comply with U.L. recommendations for break away connections at maximum distance of 6" from wall, and all other U.L. recommendations and local code requirements. Retaining angles must be wide enough to have sufficient bearing on wall (minimum surface contact of 1").
5. Damper blades and frame shall be outside of airstream, to provide a nominal 100% free area dampers.

2.8 SMOKE DAMPERS

A. Dampers shown on drawings designated as "SM" shall comply with the following:

1. All fire/smoke dampers shall have a UL label.

2. Dampers shall be provided with factory-installed, UL-rated full sleeves.

3. Provide airfoil or "V" Blade damper blades supported with shafts and stainless steel bearings to allow daily operation.

4. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems and when closed shall be the equivalent of a 1 ½ hour fire damper.

5. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G.

6. The damper manufacturer shall provide damper actuators. If dampers are pneumatically actuated, the damper manufacturer shall provide EP switch.

7. All dampers shall be provided with position indicator switches to enable remote status of open or closed positions, however, only those dampers designated in the plans and specifications as F/SM (HS), which indicate that they will be controlled from a central fire command station will be wired for remote status and remote open/closed operation.

8. Dampers that are controlled from a central fire command station shall:

   (a) Be factory-equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F. to 350°F., depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station.

   (b) The following will be accepted in lieu of the two firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150°F or less.

2.9 FIRE/SMOKE DAMPERS

A. Dampers shown on drawings designated as "F/SM" shall comply with the following:

1. All fire/smoke dampers shall have a UL label.

2. Dampers shall be provided with factory-installed, UL-rated full sleeves.

3. Provide airfoil or "V" Blade damper blades supported with shafts and stainless steel bearings to allow daily operation.

4. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems and when closed shall be the equivalent of a 1 ½ hour fire damper.

5. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G.

6. The damper manufacturer shall provide damper actuators. If dampers are pneumatically actuated, the damper manufacturer shall provide EP switch.

7. All dampers shall be provided with position indicator switches to enable remote status of open or closed positions, however, only those dampers designated in the plans and specifications as F/SM (HS), which indicate that they will be controlled from a central fire command station will be wired for remote status and remote open/closed operation.

8. Dampers that are controlled from a central fire command station shall:

   (a) Be provided with a 212°F heat sensor with normally closed contacts (manual reset) to close and lock damper if open.

   (b) Additionally, dampers shall be factory-equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F. to 350°F., depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station.

   (c) The following will be accepted in lieu of the two firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150°F or less.

   (d) Dampers that are not controlled from a central fire command station shall have a fusible link that melts on heat causing damper to close and lock in a closed position.

2.10 MISCELLANEOUS

A. When floor shut-off dampers are shown on drawings their selection shall be made so that the frames and stops of such dampers are outside of the air stream, so as to provide a nominal 100% free area damper.

B. Where fire dampers, automatic dampers or combination fire/smoke dampers are shown on drawings or are required, their selection shall be made so that the frames, stops, etc. of such dampers are outside of the airstream so as to provide a nominal 100% free area damper.

C. Furnish and install manual dampers, fire dampers, registers, grilles, register boxes, access doors, sound traps, etc., as described elsewhere in the specifications and as required for a complete system, ready for operation.

PART 3 - EXECUTION

NOT APPLICABLE.

END OF SECTION 15880

NEW PASSENGER TERMINAL
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SECTION 15920 - SOUND ATTENUATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Sound traps.

B. Sound requirements for components of air distribution systems.

1.2 RELATED DOCUMENTS

A. Section 15010 - Basic Mechanical Requirements.

B. Section 15050 - Basic Materials, Methods and Requirements (Mechanical).

C. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

D. This section is a part of each Division 15000 Section.

E. Section 09900 - Painting: Painting insulation jackets.

1.3 REFERENCES

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

C. ASTM E84 - Surface Burning Characteristics of Building Materials.

D. NFPA 255 - Surface Burning Characteristics of Building Materials.

E. UL 723 - Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE

A. Applicator: Company specializing in sound trap construction with five years minimum experience.

B. The air valve manufacturer shall submit to the Architect's representative guaranteed sound power levels by octave bands tested in accordance with ASHRAE Standard 36B-63. Ratings shall be submitted for the size valves and cfm listed on the drawings and for inlet pressures of 4, 3, 2 and 1 inch.

1.5 SUBMITTALS

A. Submit product data under provisions of Section 01300.

B. Include product description, list of materials for each service, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART 2 - PRODUCTS

2.1 FACTORY BUILT SOUND TRAPS

A. Prefabricated duct silencers shall be constructed of all incombustible materials and shall be standard product of responsible manufacturer. Pressure drop shall not exceed .25" W.G. The shell of the silencer shall be at least 22 gauge galvanized steel sheet and shall be leakproof when subjected to a differential pressure of 8 inches w.g. All sound absorbing material shall be protected by means of 24 gauge galvanized perforated steel (galvanized after punching).

B. Provide seismic restraint as described in Sections 15050 and 15245.

C. Pressure drop shall be not greater than shown on the Sound Trap Schedule. Total system pressure before and after the sound traps shall be measured after the traps are installed. Should the pressure drop be greater than specified or scheduled, the Contractor shall replace the traps and/or modify the entrance or discharge aerodynamic flow to achieve the specified results. All corrective measures shall be borne by this Contractor.

D. The sound traps shall provide the following net insertion loss ratings under design air flow velocities as scheduled on drawings and under reverberant room test method.

Bands	Band Width Center Freq. (cps)		Dynamic Net Insertion Loss (db) Sound Trap Types A	B	C	D	E	F
		IAC Type	3L	5L	3MS	5MS	3S	5S
2	125		5	7	7	10	12	18
3	250		9	13	12	18	16	24
4	500		14	21	19	30	28	40
5	1000		23	29	23	42	35	45
6	2000		24	39	23	34	35	46

E. The maximum self-generated by the above sound trap types shall not exceed the following sound power levels at face velocities of 2000 fpm.

Bands	Band Width Center Freq. (cps)	Sound Power Level db re 10-12 Watts Sound Trap Types A, B,	EF	CD
2	125	51	69	54
3	250	51	63	52
4	500	49	64	50
5	1000	47	61	47
6	2000	50	63	48

F. Certification - Certified test data of pressure drop and insertion loss ratings shall be submitted by the Contractor for a 24 x 24 cross section rectangular trap or 24 inch diameter conical trop. The Certification data for both pressure drop and insertion loss shall be based upon tests of the same trap for both measurements. The certifying laboratory shall be open to inspection and/or test of sound traps upon request of the Architect.

2.2 FACTORY BUILT SOUND TRAPS

A. Prefabricated duct silencers shall be constructed of all incombustible materials and shall be standard product of responsible manufacturer. Pressure drop shall not exceed .25" W.G. The shell of the silencer shall be at least 22 gauge galvanized steel sheet and shall be leakproof when subjected to a differential pressure of 8 inches w.g. All sound absorbing material shall be protected by means of 24 gauge galvanized perforated steel (galvanized after punching).

B. Media

1. Flamespread: maximum 25.

2. Fuel contributed and smoke developed: maximum 20.

3. Minimum 1.5 lbs per cubic foot (24 kg/m) density glass or mineral fiber packed under 5 percent compression.

4. Filler to be inert, vermin and moisture proof.

5. Protective plastic film shall be provided between air stream and fill to prevent any intermingling of the airstream with the fill material.

C. Pressure drop shall be not greater than shown on the Sound Trap Schedule. Total system pressure before and after the sound traps shall be measured after the traps are installed. Should the pressure drop be greater than specified or scheduled, the Contractor shall replace the traps and/or modify the entrance or discharge aerodynamic flow to achieve the specified results. All corrective measures shall be borne by this Contractor.

D. The sound traps shall provide the following net insertion loss ratings under design air flow velocities as scheduled on drawings and under reverberant room test method.

Bands	Band Width Center Freq. (cps)	Dynamic Net Insertion Loss (db)
2	125	9
3	250	14
4	500	19
5	1000	22
6	2000	28

E. The maximum self-generated by the above sound trap types shall not exceed the following sound power levels at face velocities of 2000 fpm.

Bands	Band Width Center Freq. (cps)	Sound Power Level db re 10-12 Watts
2	125	44
3	250	49
4	500	47
5	1000	46
6	2000	49

F. Certification - Certified test data of pressure drop and insertion loss ratings shall be submitted by the Contractor for a 24 x 24 cross section rectangular trap or 24 inch diameter conical trop. The Certification data for both pressure drop and insertion loss shall be based upon tests of the same trap for both measurements. The certifying laboratory shall be open to inspection and/or test of sound traps upon request of the Architect.

G. Sound traps within stainless steel ductwork shall be stainless steel.

2.3 ACOUSTICAL PERFORMANCE SPECIFICATIONS - GENERAL

A. Room Background Noise Criteria:

1. The maximum permissible background noise criteria in occupied spaces is included below. Mechanical equipment and distribution within and above the spaces shall be selected to meet this criteria.

	Background Nosie Criteria
Lobby / Baggage / Ticketing	NC-40
Corridors	NC-4
Concourse	NC-40
Business Center	NC-35
Administrative Offices	NC-35
Ops Conference	NC-35
Customers / Border Patrol	--------
1. Interview Rooms 2. Hold Rooms 3. Search 4. CBP Coordination 5. CBP Offices 6. Rover 7. ADIT Room 8. AG Lab	NC-35 NC-35 NC-35 NC-35 NC-35 NC-35 NC-35 NC-35
TSA Offices	NC-35
TSA Checkpoint	NC-40
Concession	NC-40
Kitchen	NC-40
Restrooms	NC-45

B. Grilles, Registers, Diffusers & Air-Light Fixtures.

1. The maximum permissible sound power levels in octave bands of grilles, registers and air-light fixtures when operated in an installed condition per plans and specifications, shall be as follows:

Octave Bands	Maximum Sound Power Level for Terminal Devices Servicing Occupied Spaces Maximum PWL re 10-12 Watts			
	NC-25	NC-30	NC-35	NC-40
1	55	60	64	66
2	45	52	56	60
3	38	44	49	54
4	32	41	46	51

Octave Bands	Maximum Sound Power Level for Terminal Devices Servicing Occupied Spaces Maximum PWL re 10-12 Watts			
	NC-25	NC-30	NC-35	NC-40
5	28	36	43	48
6	25	37	42	47
7	23	36	41	46
8	22	37	42	47

B. VAV and Fan powered terminal boxes radiated noise

1. Where terminal boxes located in ceiling plenums over occupied spaces, the maximum permissible radiated sound power levels in octave bands when operated in an installed condition per plans and specifications, shall be as follows:

	Maximum PWL (db) Re 10-12 Watts	
Octave Band Mid. Freq. (cps)	NC-35	NC-40
63	72	76
125	66	70
250	61	66
500	60	65
1000	59	64
2000	58	63
4000	56	61
8000	65	70

2. A written test report for each size unit to be used on the project shall be submitted including the radiated and discharge sound power levels in octave bands of each type and size fan powered box installed in a reverberant room with the unit operated at maximum air flow and an inlet pressure of 1.5" wg and discharge pressure of 0.3" wg. The ductwork connected to the test unit shall be installed without any sound barrier lagging within 10'-0" upstream or downstream of the box.

3. The manufacturer shall, in addition, test or provided substantiating data showing that all units have been tested in a mock-up office ceiling plenum. The mock-up office test shall be representative of the project conditions in terms of:

   (a) Ceiling plenum depth and project ceiling type.

   (b) Light fixtures and return air portions. (Note: for worst-case scenario, the light fixture and/or return air grille shall be located directly below the unit.)

   (c) Project inlet and discharge ductwork (i.e., hard ductwork).

   (d) Mock-up office walls shall terminate at the slab above, unless the project conditions indicate otherwise.

   The units shall be tested at the maximum design air flow rates and specified inlet pressures if 1.5" wg and downstream pressure of 0.3"w.g.

   The NC requirements shall be certified at maximum design air flow rates and 1.5" wg inlet pressure and 0.3" wg discharge pressure.

4. A written report of measured radiated sound pressure levels measured directly below the units shall be submitted, certifying that the unit, when operating at the design flow and inlet pressure, will permit achieving an NC environment in accordance with the established criteria in occupied spaces below the boxes.

   Any failure to meet the project requirements causing retesting shall be done so at the expense of the manufacturer (including architects, mechanical engineers and acoustical consultant's time and expenses).

B. Vaneaxial Fan Discharge Cone/Attenuator

1. Where indicated on the drawings, provide factory prefabricated vaneaxial fan diffuser cone/attenuators constructed with 26 gauge galvanized steel (perforated interior face and cone where the perforation provides 23% open free area). The cone/diffuser assembly cone shall match the diameter of the vaneaxial fan hub and the assembly shall provide the following dynamic net insertion loss when tested in accordance with ASTM-E-477.

Octave Band Center Frequency (Hz)	125	250	500	1000	2000	4000
Dynamic Insertion Loss	11	17	18	16	12	11

PART 3 - EXECUTION

3.1 SCHEDULE

A. As shown on drawings.

END OF SECTION 15920

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SECTION 15940 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the furnishing of AC individually enclosed motor controllers rated 600 V and less of the following types:

1. Across-the-line, manual and magnetic controllers.
   Reduced-voltage controllers.
2. Multispeed controllers.

B. Related Sections include the following:

1. Division 16 Section “Enclosed Controllers (Installation of).”

2. Division 16 Section “Selection of Overcurrent Devices” for OCD’s and disconnect switches used with motor controllers.

3. Division 15, “Variable Frequency Controllers”

1.3 SUBMITTALS

A. Product Data: Include dimensions and manufacturer’s technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each enclosed controller.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

(a) Enclosure types and details.

(b) Nameplate legends.

(c) Short circuit current rating of integrated unit.

(d) UL listing for series rating of overcurrent protective devices in combination controllers.
(e) Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal and control wiring.

C. Operation and Maintenance Data: In addition to items specified in Division 1 Section, include maintenance requirements.

D. Maintenance Data: For enclosed controllers and components to include in maintenance manuals specified in Division 1.

E. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are Underwriters Laboratories listed and labeled.
1. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.

B. Single Source Responsibility: Obtain similar motor control devices from a single manufacturer.

C. Comply with NFPA 70, as amended by state and local codes.

1.5 COORDINATION

A. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

B. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.
1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

2. Eaton Corporation; Cutler-Hammer Products.

3. General Electrical Company; GE Industrial Systems.

4. Siemens/Furnas Controls.

5. Square D.

2.2 ACROSS-THE-LINE ENCLOSED CONTROLLERS

A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.

1. Control Circuit: 120 V; obtained from motor power circuit via integral control power transformer of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch. Padlockable in open position.

1. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a Nationally Recognized Testing Laboratory.

2. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

3. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.

2.3 REDUCED-VOLTAGE ENCLOSED CONTROLLERS

A. Star-Delta Controller: NEMA ICS 2, closed transition with adjustable time delay.

B. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition, 50 percent voltage tap.

C. Solid-State, Reduced-Voltage Controller: NEMA ICS 2, suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.

1. Adjustable acceleration rate control utilizing voltage or current ramp, and limit motor inrush current to 150 to 300 percent of motor rated load amps.

2. Automatic acceleration kick circuitry which monitors motor current to sense when the inrush current subsides and automatically ramps voltage up at a quicker rate to eliminate the instability which occurs at the break-away torque point.

3. Surge suppressor in solid-state power circuits providing 3-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

4. LED indicators showing motor and control status, including the following conditions:

(a) Control power available.

(b) Controller on.

(c) Overload trip.

(d) Loss of phase.

(e) Shorted silicon-controlled rectifier.

5. Motor running contactor operating automatically when full voltage is applied to motor.

D. Controller includes control circuit, overload relay, and disconnecting means as specified above for across-the-line enclosed controllers.

2.4 MULTISPEED ENCLOSED CONTROLLERS

A. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:

1. Compelling relay to ensure that motor will start only at low speed.

2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.

3. Decelerating relay to ensure automatically timed deceleration through each speed.

2.5 RATINGS

A. Controllers bear U.L. short circuit ratings of 100,000 amps with appropriate line side fuses on a series rated basis, and are labeled accordingly.

2.6 WIRING

A. Wiring within controller is copper.

2.7 ENCLOSURES

A. Description: Surface mounted cabinets. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
   1. Outdoor Locations: NEMA 250, Type 3R.

B. Covers are interlocked with disconnecting means.

2.8 ACCESSORIES

A. Devices are factory installed in controller enclosure, unless other indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type. Selector switches are key operated, with key removable only in “Remote” or “Auto: position as applicable.

C. Relays: Provide auxiliary and adjustable time-delay relays as follows:
   1. Auxiliary control circuit relay for each magnetic controller NEMA Size 1 and larger, arranged to prevent holding coil currents into the external control circuit.
   2. Phase-failure and undervoltage relay for each magnetic controller size 5 and larger. Adjustable undervoltage setting.
   3. Time delay relay for each magnetic motor controller 10 HP and larger. Adjustable time closing from 0.05 to 180 seconds, arranged to delay motor starting.
   4. Undervoltage lockout relay for magnetic controllers where so indicated on drawings.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, drive, and load; and configuration of pilot device and control circuit affecting controller functions.

B. Select horsepower rating of controllers to suit motor controlled.

C. Use fractional-horsepower manual controllers for single-phase motors, unless otherwise indicated.

D. Hand-Off-Automatic (and Hand-Off-Remote) Selector Switches: Except as otherwise indicated, factory install in covers of manual and magnetic controllers of motors started and stopped by central control system and/or automatic controls or interlocks with other equipment. Make control connections so only the manual and automatic control devices that have no safety functions will be bypassed when the switch is in the hand position. Connect motor control circuit in both hand and automatic positions for safety type control devices such as low - and high - pressure cutouts , high temperature cutouts, and motor overload protectors. Switches are of the key-operated cylinder lock type, with key removable only in auto (remote) position. All locks are keyed alike.

E. Pushbutton Stations: Except as otherwise indicated, momentary-contact, start-stop units. Provide in covers of magnetic controllers for manually started motors where indicated, and connect start contact in parallel with sealing auxiliary contact for low voltage protection.

3.2 INSTALLATION

A. Installation of motor controllers will be performed as part of the work of Division 16 (Electrical).

B. Installation of motor control devices will be performed as part of the work of this trade.

3.3 CONTROL WIRING

A. Control wiring for HVAC motors is provided as part of the [Building Management System (central mechanical control system)] work of Division 15[, except for the following wiring which will be provided as part of the electrical work (Division 16):

1. For each fan motor whose operation for smoke and fire control purpose is to be automatically and/or manually controlled by the Fire Protective Alarm System (FPA), 5 #14 wires run in conduit from the motor controller [or VFC specified elsewhere] to an adjacent FPA addressable module will be provided as part of the electrical work.

2. Additional control wiring for dampers whose operation for smoke and fire control purposes by the FPA is independent of any motor start-stop control is provided as part of the electrical work.

B. Control wiring for the mechanical alarm panel is provided as part of the work of Division 15.

C. Control wiring is accomplished utilizing #14 AWG copper conductor with THWN insulation as specified in Division 16, Section "Conductors and Cables", run in conduit as specified for feeders in Division 16, Section "Raceways and Boxes".

D. Any necessary field installed make-up wiring within motor controller enclosures as required to incorporate the contained devices and accessories into the control scheme will be provided as part of the electrical work.

END OF SECTION 15940

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15942 - VARIABLE FREQUENCY CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes furnishing of solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.

B. Related Sections include the following:

1. Division 16 Section “Variable Frequency Controllers (Installation of)” for installation of VFC’s.

2. Division 15 Section “Enclosed Controllers” for control wiring.

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller.

1.4 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFC.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

(a) Each installed unit's type and details.

(b) Nameplate legends.

(c) Short-circuit current rating of integrated unit.

(d) UL listing for series rating of overcurrent protective devices in combination controllers.

2. Wiring Diagrams: Power, signal, and control wiring for VFCs, including connections for external wiring. Provide schematic wiring diagram for each type of VFC.

C. Field quality-control test reports.

D. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 1 Section “Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for VFCs and all installed components.

E. Harmonics: Submit calculations to demonstrate that the total harmonics produced by all of the VFC’s connected to the system at the electrical service point shall be no greater than the allowable harmonics as follows:

1. The total harmonics produced by all of the VFC’s connected to the system, including VFC's provided integral with HVAC equipment, at the Point of Common Coupling (PCC) shall be no greater than the allowable harmonics for “Special”,“General”,“Dedicated”] systems as specified by IEEE Standard 519 tables 10.2 and 10.3, based on the installed source KVA. The PCC shall be the primary side of the electrical service transformer(s) for calculating current distortion, and the PCC shall be the secondary side of the electrical service transformer(s) for calculating voltage distortion. Where the installed source KVA is not indicated on the Electrical drawings, calculations shall be based on 60 percent of the KVA of the service switches[, not including the fire pump.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, as amended by state and local codes.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:

1. Ambient Temperature: 0 to 40 deg C.
2. Humidity: Less than 90 percent (noncondensing).
3. Altitude: Not exceeding 3300 feet (1000 m).

1.7 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: The following vendors will be reviewed for approval providing they meet all of the performance requirements of the specifications.

1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.

2. Eaton Corporation; Cutler-Hammer Products.

3. General Electric Company; GE Industrial Systems.

4. Siemens Energy and Automation; Industrial Products Division.

5. Square D.

6. Unico, Inc.

7. Yaskawa Electric America

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.

1. Provide unit suitable for operation of standard efficiency and premium efficiency motors as defined by NEMA MG 1.

2. VFC's for operation of motors 30 horsepower and larger are equipped with 12 pulse or greater inverter sections.

3. VFC's for operation of motors less than 30 horsepower are equipped with 6 pulse or greater inverter sections.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:
1. Input ac voltage tolerance of 208 V, plus or minus 5 percent or 380 to 500 V, plus or minus 10 percent. As indicated on the equipment schedule.

2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.

3. Minimum Efficiency: 96 percent at 60 Hz, full load.

4. Minimum Displacement Primary-Side Power Factor: 96 percent.

5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.

6. Starting Torque: 100 percent of rated torque or as indicated.

7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

F. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.

2. Maximum Speed: 80 to 100 percent of maximum rpm.

3. Acceleration: 2 to a minimum of 22 seconds.

4. Deceleration: 2 to a minimum of 22 seconds.

5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

G. Self-Protection and Reliability Features:

1. Input transient protection by means of surge suppressors.

2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.

3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 performance.

4. Skip frequencies: Drive is arranged to skip a minimum of 3 field adjustable frequencies where the controller-motor-load combination operates at a natural resonant frequency of the combination. Each is adjustable with a selectable bandwidth.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor over-temperature fault.
10. Control circuit (120 volts) for interlocking with dry contacts in load side motor disconnect to disable start-up attempts with system open.
11. Snubber networks to project against malfunction due to system voltage transients.

H. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.

I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Attempts unlimited restarts after controller fault or on return of power after an interruption where serving motors used for smoke control systems, with no manual intervention required. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

M. Decelerating Energy Absorption: Means of absorbing energy released by decelerating motor (and its driven load) without damage to VFC, motor, or load.

N. Input Line Conditioning: Line reactors (5 percent) on 6 pulse VFCs to reduce harmonics produced by the VFC's.

1. Protect each VFC against injurious overheating at its full load rating.

2. Line reactors / passive harmonic filters are incorporated as an integral part of the controller equipment in a single cabinet. Where factory-mounting of VFC's are provided on packaged equipment, it is acceptable to mount remotely. Include all required field wiring.

3. The harmonic mitigation equipment shall treat all of the characteristic low frequency harmonics generated by a 3-phase, diode bridge rectifier load (5th, 7th, 11th, 13th, etc.).

4. The characteristic harmonics shall be suppressed without the need for individual tuning or the requirement to phase shift against other harmonic sources.

5. Harmonic mitigation shall be by passive inductor/capacitor network. Active electronic components shall not be used.

6. Power factor shall be .98 lagging to .95 leading in operating range from full to half load.

7. To ensure compatibility with engine generators, the harmonic mitigation equipment must never introduce a capacitive reactive power (KVAR), which is greater than 20% of its kVA rating.

8. The harmonic mitigation equipment shall not resonate with system impedances or attract harmonic currents from other harmonic sources.

9. The harmonic mitigation equipment in combination with the Variable Frequency Drive shall meet all requirements as outlined in the 1992 edition of IEEE std 519 for individual and total harmonic voltage and current distortion. The Point of Common Coupling (PCC) for all voltage and current harmonic calculations and measurements shall be the input terminals to the harmonic mitigation equipment.

10. Total Harmonic Voltage Distortion (THVD) shall meet the requirements of Table 10.2 of IEEE std 519 by not exceeding 5% and by limiting the individual harmonic voltage distortion to less than 3%. These limits shall apply while operating on either utility supply or generator supply when applicable. The harmonic mitigation equipment vendor shall not be responsible for pre-existing voltage distortion caused by other harmonic sources.

11. Total Demand Distortion (TDD) of the current at the input terminals of the harmonic mitigation equipment shall not exceed the limits as defined in Table 10.3 of IEEE std 519. For Isc/IL ratio < 20, TDD must be less than 5%. For all other Isc/IL ratios, the TDD must not exceed 8% even when Table 10.3 allows for more relaxed limits. For single-phase applications, the TDD must not exceed 12%.

12. The full load efficiency of the harmonic mitigation equipment / VFD combination shall be greater than 96%. The harmonic mitigation equipment itself shall have efficiency no less than 99%.

13. Maximum of one drive shall be connected a single filter.

O. DC Bus choke: For harmonic distortion reduction.

P. VFC Output Filtering: The variable frequency controllers are suitable for use with standard NEMA Design B motors having a service factor of 1.15 without producing any injurious “ringing” over-voltages as the motor terminals. Incorporate L-C filters (and/or other items) in the output of the drive as required to prevent such over voltages based on the circuit length from VFC to motor. Provide written certification of the suitability of the VFC for use with “standard motors.”

Q. Status Lights: Door-mounted LED indicators shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

R. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

S. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

T. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V and 0/4-20 mA) and 6 programmable digital inputs.

2. Pneumatic Input Signal Interface: 3 to 15 psig (20 to 104 kPa).

3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   (a) 0 to 10-V dc.

   (b) 0-20 or 4-20 mA.

   (c) Potentiometer using up/down digital inputs.

   (d) Fixed frequencies using digital inputs.

   (e) RS485.

   (f) Keypad display for local hand operation.

4. Output Signal Interface:
   (a) A minimum of 2 analog output signals (0/4-20 mA), which can be programmed to any of the following:

      (1) Output frequency (Hz).

      (2) Output current (load).

      (3) DC-link voltage (VDC).

      (4) Motor torque (percent).

      (5) Motor speed (rpm).

      (6) Set-point frequency (Hz).

5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of each of the following:
   (a) Motor running.

   (b) Set-point speed reached.

   (c) Fault and warning indication (overtemperature or overcurrent).

   (d) PID high- or low-speed limits reached.

6. Damper Control Interface: Closes a dry contact upon a start command to open associated dampers before the motor is allowed to operate in drive or bypass mode. Input to accept damper limit switch contact closure to allow the motor to operate.

7. Safety Control Interface: Input to accept safety device dry contact closure to stop motor operation in drive and bypass mode.

8. Over-ride Control Interface: Input to accept control system dry contact closure to start motor operation in drive mode at variable speed and in bypass mode.

U. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control, and all output signals and alarms of VFC to be monitored by BMS. Provide capability for VFC to retain settings programmed via BMS control within the nonvolatile memory.

V. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

W. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode. Bypass controller for motors 75 HP and larger (10 HP and larger where supplied from an emergency generator) are provided with solid-state reduced voltage controller (soft-start) in series with the bypass contactor, as specified in Division 15 Section “Enclosed Controllers”.

X. Integral Disconnecting Means: NEMA KS 1, nonfusible switch with lockable handle.

Y. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

2.3 ENCLOSURES

A. NEMA 250, Type 1 enclosure unless otherwise indicated.

B. NEMA 250, Type 4 enclosure where located outdoors. Heater and air-cooled cooling unit to maintain temperature within housing as required for proper operation for outdoor temperatures within the range of the ASHRAE 99.6 percent winter design temperature and ASHRAE 0.4 percent summer design temperature for the area, plus solar load. Single point electrical connection for controller and enclosure.

2.4 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Control Relays: Auxiliary and adjustable time-delay relays.

D. Standard Displays:

1. Output frequency (Hz).

2. Set-point frequency (Hz).

3. Motor current (amperes).

4. DC-link voltage (VDC).

5. Motor torque (percent).

6. Motor speed (rpm).

7. Motor output voltage (V).

2.5 FACTORY FINISHES

A. Manufacturer's standard prime-coat finish ready for field painting.

B. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 APPLICATION

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, drive and load.

B. Select rating of controllers to suit motor controlled.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:

1. Inspect variable frequency controllers, wiring, components, connections, and equipment installation. Test and adjust variable frequency controllers, components, and equipment in accordance with NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameter.

2. Operate variable frequency controller throughout its full frequency range and program to skip frequencies where the controller-motor-load combination operates at a natural resonant frequency of the combination.

3. Complete installation and startup checks according to manufacturer's written instructions.

4. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

B. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

4. Report results in writing.

3.3 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 1 Section “Demonstration and Training."

3.4 INSTALLATION

A. VFC’s to be installed as part of Division 16 work.

3.5 CONTROL WIRING

A. Provide control wiring as specified in Division 15 Section “Enclosed Controllers”.

END OF SECTION 15942

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1. Section 15010 - Basic Mechanical Requirements.
2. Section 15050 - Basic Materials, Methods and Requirements (Mechanical)
3. This section is a part of each Division 15000 Section (Mechanical).
4. Specified elsewhere:
   a. Variable Speed Control
   b. Motors
   c. HVAC Pumps
   d. Chillers
   e. Cooling Tower
   f. Boilers
   g. Terminal Air Distribution
   h. Fans
   i. Air Handling Units
   j. Testing, Adjusting and Balancing
   k. Basic Elec. Materials Methods
   l. Electrical Wiring

B. Technical Proposals

1. Technical proposals shall be prepared in accordance with these specifications. Four (4) copies of the proposal shall be submitted with the bid. Proposals that are unbound, loose, loose in a file folder, stapled, stapled in a manila file folder, etc., will not be acceptable. The technical proposal shall include the following data/information as a minimum. The order of listing here is not intended to indicate, nor should it be construed to indicate, the relative importance of the data/information:

   a. Information on organizational capability to handle this project (management, personnel, manufacturing, single source responsibility, etc.). Provide an organizational chart of the local factory branch office indicating the project team and each person's role in the project. Provide a resume for each project team member and all management personnel.

   b. A comprehensive bar chart project schedule indicating submission of shop drawings, equipment delivery, installation, start-up commissioning, training, milestones, and all critical path tasks.

   c. A project specific on-site and off-site training program which demonstrates specification compliance.

d. BMS Configuration as Proposed:

1) Modularity.

2) Provisions against obsolescence due to technological advancement.

3) Detailed description of all operating, command, application and energy management software provided for this project.

4) Provide a riser drawing of the system architecture. The drawing shall indicate the model number, location and service of each primary control panel, secondary control panel, PC workstation and all other network hardware.

5) A complete description of the chiller plant integration and/or optimization package, if applicable.

6) A complete description of all interface and/or integration packages.

7) Provide a complete submittal of all hardware, software, sensors and end devices (valves, damper operators, airflow stations, etc.).

8) Description of manual override operation and BMS monitoring of manual override operation and BMS monitoring of manual override for each type control point in system.

9) A list of references (include Owner contact name and phone number) for five (5) projects completed by the local branch office within the last five years of similar size, schedule and complexity.

10) A line by line BMS specifications concordance summary. The summary shall be in table form and indicate each article and paragraph by number and whether the proposed BMS contractor “Does Comply” or “Does Not Comply” with the paragraph. If the item does not comply, the bidder shall provide a written explanation.

11) A signed certificate stating the Contractor “has read the performance and functional requirements, understands them, and the technical proposal will comply with all parts of the specification” or a signed line by line specification concordance statement. Certificate or statement shall be signed by a person having the authority to guarantee the statement.

1.2 SUMMARY

A. General Work Description

1. Building Management System (BMS) controls contractor shall provide:

   a. A fully integrated building management system (BMS), UL-listed, incorporating direct digital control (DDC) for energy management, equipment monitoring, and HVAC control.

   b. Electronic sensors.

   c. Actuators of terminal equipment valves and dampers shall be electric. All sensors shall be electric/electronic.

   d. Actuators for valves and dampers located within the MER's shall be electric.

   e. All line voltage and low voltage wiring, conduit, panels, and accessories for a complete operational system. All final electrical connections to each stand-alone DDC Controller.

   f. BMS Contractor shall be responsible for all electrical work associated with the BMS and as shown in the contract documents. The BMS contractor shall be responsible for all electrical work associated with any BMS interface to any other systems including but not limited to HVAC and plumbing systems.

   g. The BMS contractor shall furnish all wells for water monitoring devices, flow switches, and alarms.

   h. A complete operational system including all work required for a completely operational system as defined in the entire set of drawings and specifications, including but not limited to associated specifications for mechanical and electrical work, all contract drawings, BMS Point List, and remote function schedule.

   i. The BMS system as a whole shall have the capability to be easily expanded through the addition of point modules and/or controllers. No equipment shall be installed which cannot, as installed, accommodate an upgrade the entire system by at least 25%. A 25% system upgrade shall include 25% more points (of each type) either via point modules or controllers and 25% more memory capacity for future connections.

   j. Provide appropriate labor jurisdiction to mount, wire and pipe airflow measuring stations in the field. Provide manpower as required to meet project schedule.

1.3 DEFINITIONS

A. AI - Analog Input

B. ANSI - American National Standards Institute

C. AO - Analog Output

D. ASCII - American Standard Code for Information Interchange

E. AWG - American Wire Gauge

F. BMS - Building Management System

G. CPU - Central Processing Unit

H. CRT - Cathode Ray Tube

I. DAC - Digital to Analog Converter

J. DDC - Direct Digital Control

K. DI - Digital Input

L. DO - Digital Output

M. EEPROM - Electronically Erasable Programmable Read Only Memory

N. EMI - Electromagnetic Interference

O. FAS - Fire Alarm Detection and Annunciation System

P. HOA - Hand-Off-Auto

Q. IEEE - Institute of Electrical and Electronics Engineers

R. I/O - Input/Output

S. LAN - Local Area Network

T. LCD - Liquid Crystal Display

U. LED - Light Emitting Diode

V. MCC - Motor Control Center

W. NC - Normally Closed

X. NO - Normally Open

Y. OWS - Operator Workstation

Z. OAT - Outdoor Air Temperature

AA. PC - Personal Computer

BB. RAM - Random Access Memory

CC. RFI - Radio Frequency Interference

DD. RH - Relative Humidity

EE. ROM - Read Only Memory

FF. RTD - Resistance Temperature Detector

GG. TCP/IP - Transmission Control Protocol/Internet Protocol

HH. UPS - Uninterruptible Power Supply

II. VAC - Volts, Alternating Current

JJ. VAV - Variable Air Volume

KK. VDC - Volts, Direct Current

LL. WAN - Wide Area Network

1.4 SYSTEM DESCRIPTION

A. General Product Description

1. The building management system (BMS) shall integrate multiple building functions including equipment supervision and control, alarm management, energy management and historical data collection.

2. The building management system shall consist of the following:

a. Independent, Primary Control Panels (PCPs) for control of each air handler, each AC unit, each chiller, each pumping system, and each hot and chilled water system (including pump control). The intent of this specification is that the loss of any one Primary Control Panel shall affect only the points connected to that specific PCP and shall not affect the operation of any other HVAC system. Motors in motor control centers shall be controlled only from Primary Control Panel associated with the respective HVAC system. It shall not be acceptable to control all motors in a MCC from a Primary Control Panel(s) dedicated to the MCC.

b. Stand-alone, Secondary Control Panels for terminal equipment only (CAV, FP VAV, VAV units, EDH, Fancoil, etc.).

c. Portable operator's terminals (POTs) to be connected and communicating simultaneously with the entire Primary Network from any Primary Control Panel. The portable operators terminals shall be able to simultaneously monitor, adjust, trend, edit, modify, add,

delete, backup the entire B.M.S system (including Secondary Control Panels, Primary Control Panels, etc.) point database and all programs.

d. Personal computer operator workstation(s) and associated peripherals. The personal computer operator workstation shall reside on the same network as the primary control panels.

3. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Primary Control Panels, Secondary Control Panels and operator devices.

4. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each Primary Control Panel shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection (including a wire break) shall affect only the system controlled by the specific PCP and shall not interrupt the operation of any other SCP, PCP, etc. In addition, the failure shall not affect or interrupt the execution of any control strategy, reporting, alarming and trending function, or any function at any operator interface device.

5. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panels or combination of Primary Control Panels on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

6. Operators shall be able to assign password access and control priorities to each HVAC system or interfaced system individually. The logon password (at any PC workstation or portable operator terminal) shall enable the operator to monitor, adjust and control only the system that the operator is authorized for. All other systems shall not be displayed at the PC workstation or portable terminal. Passwords and priority levels for every system shall be fully programmable and adjustable. This provision shall be applicable to all systems accessed either locally or remotely.

1.5 SEQUENCE OF OPERATION

A. Refer to Section 15951 for Sequence of Operations.

1.6 SUBMITTALS

A. General

1. Indicate at the beginning of each submittal, all substitutions and deviations from requirements of Contract Documents.

B. Product Data

1. Technical bulletins and catalog data for all equipment and system components. Clearly identify, by use of symbol or tag number, the service of each item. All irrelevant information shall be marked out leaving only pertinent data.

C. Shop Drawings

1. Shop drawing submittals shall comply with Division 1 and other specified requirements and shall include sufficient data to indicate complete compliance with Contract Documents. Submission shall be in the form of drawings, brochures, bulletins, catalog data and/or narrative descriptions.

2. Submission shall include, but not be limited to:

a. Symbol and abbreviation lists.

b. System block diagram showing quantity and location of personal operator workstation(s), Primary Control Panels, Secondary Control Panels, and locations of power feeds to BMS and other major system components. Show quantity and location of compressed air plant if compressed air plant is specified.

c. Control diagrams for all systems controlled. Controls shall be shown on system flow diagrams.

d. Power wiring diagrams and electrical requirements.

e. Interfaces (software and hardware) with other equipment provided in other sections of specifications including but not limited to chiller control system.

f. Narrative description of operation for each system, enumerating and describing the function of each component. Include alarm and emergency sequences, and equipment interlocks.

g. Description of manual override operation for every input and output point.

h. Complete input/output point schedule. Identify point function, type and location.

i. Spare capacity provisions.

j. Detailed bill of materials.

k. Valve and damper schedule: Provide identification numbers, location, system, dimensions and performance data. Include damper leakage rates.

l. Device mounting details. Include as a minimum:
   1) Sensing elements in ducts and casings.
   2) Sensing elements in piping.

m. Ladder wiring diagrams.

n. Other information as requested herein.

o. Complete full size drawings, 11" x 17" minimum.

D. Programming

1. Point identification code.

2. System advisory messages, printouts, logging formats.

3. Drawings of system graphics showing monitored points. (Include only if graphics are specified elsewhere in this specification).

4. Software flow-charts for applications and DDC programs.

5. Person machine interface program, including commands, alarm annunciation, logs and programming capabilities.

6. Description of system operation under failure conditions.

E. Samples

1. All wall, pipe and duct sensors.

2. All other devices mounted on finished surfaces.

3. Valve, damper, panel and sensor tags.

F. Quality Control Submittals

1. UL, FM, CSA listing compliance certificates.

2. Final calibration, commissioning and testing reports.

G. Time Requirements

1. Within thirty (30) days of award of contract manufacturer shall provide schedule of all submittals employing format as provided hereinafter and enumerating all drawings, samples and miscellaneous submittals by name, quantity, etc.

1.7 QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of automatic temperature control systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. All portions of the system must be of the same manufacturer and must be designed, furnished, installed, commissioned and serviced by manufacturer employed, factory trained employees. Systems proposed by distributors, manufacturer's representatives, and/or independent contractors shall not be considered and are not acceptable.

C. Single source responsibility of supplier shall be the complete installation and proper operation of the BMS and control system and shall include debugging and proper calibration of each component in the entire system.

D. Supplier shall have an in-place support facility within 50 miles of the site with technical staff, spare parts inventory and all necessary test and diagnostic equipment.

E. All electronic equipment shall conform to the requirements of FCC Regulation, Part 15, Section 15, Governing Radio Frequency Electromagnetic Interference and be so labeled.

F. BMS shall comply with UL 916 PAZX and 864 UDTZ and be so listed at the time of bid.

G. System devices shall have UL 864 (UUKL smoke control) and shall be so certified at time of bid.

H. All system components shall be fault-tolerant. System shall include:

1. Satisfactory operation without damage at 110% and 85% of rated voltage and at plus 3 Hertz variation in line frequency.

2. Static, transient and short-circuit protection on all inputs and outputs.

3. Protection for communication lines against incorrect wiring, static transients and induced magnetic interference.

4. Network-connected devices to be AC coupled or equivalent so that any single device failure will not disrupt or halt network communication.

5. All real time clocks and data file RAM to be battery-backed for a minimum 72 hours and include local and remote system low battery indication.

I. The Bidder shall be regularly engaged in the manufacturing, installation and maintenance of BMS systems and shall meet the following qualifications.

1. A minimum of ten (10) years of demonstrated technical expertise and experience in the manufacture, installation and maintenance of BMS systems similar in size and complexity to this project.

2. A maintained service organization consisting of at least ten (10) competent servicemen, within 50 miles of the project site, for a period of not less than ten years.

3. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last five years.

J. The system manufacturer/installer shall provide a full-time, experienced project manager for this work from beginning of control installation until final completion. The project manager responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion.

K. Comply with all current governing codes, ordinances, and regulations including UL, NFPA, the local Building Code, NEC, etc.

L. The manufacturer of the building management system shall provide documentation supporting compliance with ISO-9002 (model for Quality Assurance in Production, Installation and Servicing). The intent of this specification requirement is to ensure that the products and services that the manufacturer and installer provide are delivered through a Quality System and Framework that will assure consistent quality throughout the project.

M. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

N. In order to ensure the availability of rapid response, the BMS Contractor shall have a local facility or authorized service agent within a 50-mile radius of the job site. On-site emergency service shall be available on a 24-hour, 7-day-a-week basis.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to unit manufacturer.

1.9 COORDINATION

A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.

B. Coordinate equipment with Division 13 Section "Intrusion Detection" to achieve compatibility with equipment that interfaces with that system.

C. Coordinate equipment with Division 13 Section "Clock Control" to achieve compatibility with equipment that interfaces with that system.

D. Coordinate equipment with Division 13 Section "Lighting Controls" to achieve compatibility with equipment that interfaces with that system.

E. Coordinate equipment with Division 13 Section "Fire Alarm" to achieve compatibility with equipment that interfaces with that system.

F. Coordinate supply of conditioned electrical circuits for control units and operator workstation.

G. Coordinate equipment with Division 16 Section "Panelboards" to achieve compatibility with starter coils and annunciation devices.

H. Coordinate equipment with Division 16 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

I. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3 Section "Cast-in-Place Concrete."

1.10 EXTRA MATERIALS

A. Furnish extra materials described below to match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. Replacement Materials: Provide one replacement component for each unique control device including as a minimum:

1. Panels:

a. DDC panel board components.

b. Relays.

c. Power supplies and transformers.

2. Field input devices:

a. Space, air and water temperature sensors.

b. Space and air humidity sensors.

c. Air and water differential pressure transmitters.

d. Static pressure transmitter.

e. Air and water differential switch.

f. Freezestat

g. Current switches.

3. Field output devices:

   a. Actuators for dampers and valves excluding butterfly valves.

   b. Electric-pneumatic transducers or switches.

C. Maintenance Materials: Any unique or special tools that are required for proper operation, maintenance and repair as outlined in the system operation, maintenance and repair manuals shall be provided.

D. Provide a complete list of replacement and maintenance materials in the technical proposal.

1.11 RECORD DOCUMENTS

A. Owner’s Manual General

1. Submit two (2) draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and shall submit four (4) interim final copies. Upon completion of project, acceptance of project by the owner, submit six (6) copies of final "as built" manuals and one (1) reproducible copy (3-mil sepia Mylar).

2. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above for "as built" manuals.

3. Assemble owner's manuals into multi-volume sets.

4. Protect each volume with a heavy-duty vinyl plastic binder. Volumes to have plastic printed dividers between major sections and have oversized binders to accommodate up to _ inch thick set of additional information.

5. Each binder to be silk screened with project name and volume title on front cover and binder.

6. On the first page of each manual identify with project name, title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.

B. Provide an operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. Include as a minimum:

1. Control flow diagrams for all building systems.

2. Sequence of operation for automatic and manual operating modes for all building systems. The sequences shall cross-reference the system point names.

3. Description of manual override operation of all control points in system.

4. BMS system manufacturer's complete operating manuals.

C. Provide a maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. Include as a minimum:

1. Complete as-built installation drawings for each building system.

2. Overall system electrical power supply scheme indicating source of electrical power for each system component. Indicate all battery backup provisions.

3. Overall system shielding and grounding scheme indicating all major components and ground paths.

4. Drawings showing installation details and locations of equipment.

5. Charts showing normal operating conditions at significant points such as electrical test points.

6. Routine preventive maintenance procedures, corrective diagnostics troubleshooting procedures, and calibration procedures.

7. Parts lists with manufacturer's catalog numbers and ordering information.

8. Lists of ordinary and special tools, operating materials supplies and test equipment recommended for operation and servicing.

9. Manufacturer's operating, set up, maintenance and catalog literature for each piece of equipment.

10. Maintenance and repair instructions.

11. Recommended spare parts.

12. Field test reports.

D. Provide a programming manual to serve as training and reference manual for all aspects of system programming. Include as a minimum include the following:

1. Complete programming manuals and reference guides.

2. Details of any special software packages and compilers supplied with system.

3. Information required for independent programming of system.

4. Point schedule including all points, real and pseudo.

5. Project specific software troubleshooting procedures.

E. Maintenance Data and Operating Instructions:

1. Maintenance and operating manuals in accordance with Section 01010, General Requirements.

a. Prepare data in the form of an instructional manual.

b. Contents: Prepare a Table of Contents for each volume, with each Product or system description identified, in three parts as follows:

1) Part 1: Directory, listing names, addresses, and telephone numbers of Architect/Engineer, Contractor, Subcontractors, and major equipment suppliers.

2) Part 2: Operation and maintenance instructions arranged by system and subdivided by specification section. For each category, identify names, addresses, and telephone numbers of Subcontractors and suppliers. Identify the following:

a) Significant design criteria.

b) List of equipment.

c) Parts list for each component.

d) Operating instructions.

e) Maintenance instructions for equipment and systems.

3) Part 3: Project documents and certificates, including the following:

a) Shop drawings and product data.

b) Certificates.

c) Photocopies of warranties.

d) Photocopies of bonds.

2. Contents, Each Volume

a. Table of Contents: Provide title of project; names, addresses, and telephone numbers of Architect/Engineer, Sub-consultants and contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.

b. For each Product or System: List names, addresses and telephone numbers of Subcontractors and suppliers, including local source of supplies and replacement parts.

c. Product Data: Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.

d. Drawings: Supplement product data to illustrate relations of components parts of equipment and systems, to show control, flow and wiring diagrams. Do not use Project Record Documents as maintenance drawings.

e. Narrative Text: As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's instructions.

f. Warranties.

g. Bonds.

3. Manual for Equipment and Systems

a. Each item of equipment and each system: Include description of unit or system and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and tests, and complete nomenclature and model number of replaceable parts.

b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.

c. Include color-coded wiring diagrams as installed.

d. Operating Procedures: Include start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any special operating instructions.

e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance and trouble shooting; disassembly repair, and re-assembly instructions; and alignment, adjusting, balancing, and checking instructions.

f. Provide servicing and lubrication schedule for dampers and actuators and list of lubricants required.

g. Include manufacturers printed operation and maintenance instructions.

h. Include sequence of operation by BMS manufacturer.

i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams required.

j. Provide control diagrams by controls manufacturer as installed.

k. Provide BMS contractor's coordination drawings, with color coded control piping diagrams as installed.

l. Provide list of original manufacturers' spare parts, current prices, and recommended quantities to be maintained in storage.

m. Additional requirements as specified in individual Product specification sections.

n. Provide a listing in Table of Contents for design data, with tabbed dividers and space for insertion of data.

4. Instruction of Designated Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.

b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

5. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

6. Furnish required number of manuals, in bound form containing data covering capacities, maintenance and operation of all equipment and apparatus. Operating instruction shall cover all phases of control and include the following:

a. Lubrication Schedule: Indicating type and frequency of lubrication required for dampers and actuators.

b. List of Spares: Recommended for normal service requirements.

c. Parts List: Identifying the various parts of the equipment for repair and replacement purposes.

d. Instruction Books may be standard booklets but shall be clearly marked to indicate applicable equipment.

e. Wiring Diagrams: Generalized diagrams are not acceptable, submittal shall be specifically prepared for this Project.

7. Instruct Owner on the maintenance instructions for draining and protecting chilled water coils in the winter.

F. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

G. Record Drawings

1. The BMS contractor shall provide a complete set of "as-built" or record drawings. The drawings shall be prepared and delivered to the architect in an acceptable AutoCAD format.

2. The drawings shall indicate:

   a. All BMS work installed exactly in accordance with the original design.

   b. All BMS work installed as a modification or addition to the original design.

   c. The dimensional information necessary to delineate the exact location of all wiring runs that are so concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance. Where shop drawings have been prepared and approved, the "as-built" drawings shall be cross-referenced to the respective shop drawing.

   d. All wiring routing locations must be shown.

3. As-built record drawings shall include the updating of all equipment schedule sheets.

4. The record drawings shall be reproducible as directed.

5. The BMS Contractor shall make arrangements with the Engineer to obtain design drawings on CD ROM disks in AutoCAD format for use as a basis for the "as-built" drawings. These documents remain the property of Cosentini Associates and shall not be used for any other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

6. Prior to developing any "as-built" drawings, the contractor shall coordinate with the Owner and the Architect Engineer the drawing layers, etc., of the CAD drawings.

7. "As-built" information shall be submitted as follows:

   a. CAD drawing files on CD ROM disks in AutoCAD format. The version of AutoCAD to be utilized shall be the version in use by the Engineer at the time of the submission.

   b. Two (2) sets of reproducible drawings.

   c. Three (3) sets of blueprints.

8. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

9. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.

10. This trade shall submit the "as-built" set for approval by the building department in a form acceptable to the department, when required by the jurisdiction.

11. The contractor shall provide files on disks in an ASCII format for all schedules, catalog information, installation instructions manuals (information) indexed by system and/or equipment.

12. All equipment and systems require proper identification and tagging, including a system description. This information must be coordinated with all design and shop drawings.

1.12 WARRANTY

A. The Contractor shall warranty the BMS to be free from defects in workmanship and material for a period of one (1) year from the date of acceptance by the Owner. During the warranty period, the Contractor shall furnish all labor to repair or replace all items or components that fail due to defects in workmanship or material. This contractor shall also provide all system software upgrades during the warranty period.

B. The Contractor shall provide an on-line troubleshooting service during the warranty period. The on-line system shall allow the contractor or owner's agent the ability to interrogate, troubleshoot and correct warranty defects remotely. This system shall be operational 24 hours a day, 365 days a year. If the local manufacturer's staff cannot resolve the problem, the corporate home office staff shall remotely connect to the system and troubleshoot the warranty defect.

C. The Contractor shall submit a written report within 3 days of all warranty defects, the action taken, and corrections made for each warranty call.

D. Extended Maintenance Contract (Alternates 1 & 2)

1. **ALTERNATE 1**: The BMS contractor shall provide, as part of the base bid price, a one-year preventative maintenance service contract covering all parts, materials, software, hardware, and all costs to provide software and hardware upgrades during the warranty period. The service contract shall include the following at a minimum:

a. Periodic maintenance (preventive and corrective maintenance). A minimum of one eight (8) hour on-site preventative maintenance days per month shall be provided;

b. Recommended spare parts;

c. Emergency service 24 hours a day, 7 days a week, 365 days per year. Response to emergency calls shall be made within 1 hour by phone and 4 hours on-site. Emergency hours shall not be deducted from preventive maintenance time.

d. "Dial in Services" for troubleshooting via modem 24 hours a day, 7 days per week, 365 days per year. Maximum contractor response time shall be 2 hours.

2. **ALTERNATE 2:** The BMS contractor, as an alternate, shall provide a bid price to extend the maintenance service contract and the warranty, as specified herein, for four additional years following the warranty period.

   a. The maintenance services to be provided in both the base bid and the alternate bid shall include, but are not limited to, the following: (refer to equipment schedules, and control drawings to point, equipment and systems count).

   b. General

      1) All control items are to be maintained even if they were not installed under this contract.

      2) The following are the minimum services required by the owner. If additional services to maintain the warranty are requested by the manufacturer or contained in the manufacturer's maintenance documentation, these services shall be included in both the base and alternate the bid.

      3) All maintenance procedures must be as per the manufacturer's recommendation and not void any warranties.

      4) All maintenance procedures must be performed on all systems and equipment based on good standard industry practices or from the owner's direction.

      5) The BMS maintenance contractor must coordinate the PM program with any existing or new maintenance management system whether installed by this contractor or others.

      6) The "Standard Terms and Conditions" for this contract will be provided by the facility.

   c. Network

      1) Monthly

         a) The BMS contractor shall provide all software and electronic hardware upgrades as upgrades become available.

         b) Provide newly released software documentation updates, field support and technical bulletins.

         c) Provide operator support in identifying and resolving problems with software, operations or programming.

2) Quarterly

a) Perform diagnostics on the network to analyze trunk traffic and optimize the trunk.

b) Perform system file back up, field panel database and graphics database backup.

c) Create or modify operator workstation(s) graphics as necessary to reflect changes in the system.

3) Semi-annually

a) Remove cylinder valves and inspect for wear, broken valve spring s, broken valve discs, and damaged valve seats. If necessary, clean and repair.

b) Drain crankcase oil, clean interior of crankcase, and refill with new oil.

c) Inspect cylinder bore to be sure cylinder receiving proper lubrication.

d) Check for loose foundation bolts and tighten if necessary.

e) Drain oil and clean force-feed lubricator oil reservoir.

f) If compressor piston assembly is of the non-lubricated type, remove piston and check piston rings, piston rod and compressor cylinder bore for wear.

g) Remove piston rod packing and piston rod oil scraper ring. Check for wear and clean (if necessary). Important: Don’t intermix packing ring or oil scraper ring segment.

4) Annually

a) Remove, clean and inspect inter-cooler tube, bundles, aftercooler tube bundles and clean interior of cooler shells.

b) Drain water and clean cylinder and cylinder water jackets.

c) Check and clean (if necessary) compressor motor.

d) Check and inspect compressor drive belts for wear and adjustment.

e) Check for wear and inspect main bearing, crank bearing, and wrist pin bushings.

f) Check crankshaft counterweights for tightness.

g) The same procedure should be followed for annual inspection as described in daily, monthly and semi-annual inspection information.

d. Primary and Secondary Control Panels

1) Monthly

a) Verify regulated power assembly and battery voltages. Adjust if required.

b) Ensure cabinet is at earth ground potential.

c) Verify proper system electrical ground isolation.

d) Inspect interconnecting cables and electrical connections.

e) Via personal computer operator workstation, exercise controlled devices with manual command functions and verify proper response of connected field hardware. Check for alarms and overrides using note specific alarms and overrides.

f) Inspect HOA switches for proper position. Coordinate activation of HOA switch test w/owner.

g) Perform built-in, field panel diagnostic tests.

h) Perform integrity test and system wide function test through random point checks, commands, selective disabling, and standard field cabinet reports.

i) Note system points that are in override condition and review with building engineer.

j) Note system points that are in alarm condition and review with building engineer.

k) Review personal computer operator workstation(s) log book with engineer.

2) Annually

a) Clean external surfaces of panel enclosure and associated primary and secondary controllers.

b) Exercise point value display and run diagnostic self-test on primary and secondary control panels.

c) Inspect interior surfaces and components of panel enclosure and associated primary and secondary control panels and clean if required. Ensure all mounted devices and plug-in components are securely in place.

d) Evaluate binary and analog points for proper operation and reporting. At the personal computer operator workstation, make a general performance review of all points.

e) Check individual critical points. Determine new or revised calibration coefficients as required. Make adjustments to connected field devices as required.

f) Enter new revised calibration coefficients into software after completing critical point procedures for each primary or secondary control panel.

g) Upgrade control panel firmware and software with new version as available.

h) Review control loops for proper operation at a time when controlled conditions are stable and at setpoint. If necessary, verify or adjust tuning constraints (proportional/integral gains, etc.), setpoints, parameters, and/or reset schedules.

i) Record any parameter values that are different than those shown on program listing.

j) Label and date all field devices that have been changed or added.

e. All Control Valves

1) Semi-Annually

a) Visually inspect all control valves including reheat valves. Repair and/or replace all observed deficiencies including but not limited to leaking valves, improper connection of wiring, etc.

b) Check to ensure control valves are providing a tight shut-off of controlled medium. Replace trim components as required.

c) Operate control valves over full modulation range to ensure proper operation. Adjust as required.

d) Inspect condition of valve actuator. Operate actuator over full modulation range to ensure proper operation. Repair/replace all defective components.

e) If pneumatic actuation, check all pilot positioners. Repair/replace as required.

f. All Control Dampers (including smoke dampers)

1) Semi-Annually

a) Check damper linkage, setscrews, and blade adjustment for proper tightness. Lubricate as required.

b) Operate dampers over full modulation range to ensure proper operation. Adjust as required. Repair/replace all defective components.

c) Inspect condition of damper actuators. Operate actuators over full modulation range to ensure proper operation. Repair/replace all defective components.

d) If pneumatic actuation, check all pilot positioners. Repair/replace as required.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Electric, Electronic, and DDC Systems:

a. Alerton, IBEX or BACTalk.

b. Andover, Continuum.

c. Honeywell Inc., Excel 5000.

d. Johnson Controls Inc., Metasys.

e. Invensys, I/A.

f. Siemens Inc., System 600 Apogee.

g. Automated Logic, Eikon or Web CTRL.

2.2 SYSTEM ARCHITECTURE

A. The Building Management System (BMS) is designed to support the comfort, safety, and productivity of the building's occupants and property. BMS shall integrate multiple building functions including equipment supervision and control, alarm management, energy management, information management, and historical data collection and archiving.

B. The BMS shall use an open architecture and fully support a multi-vendor environment. To accomplish this, the BMS shall be able to use open communication protocol standards, a wide variety of third-party devices, applications via existing vendor protocols, as well as the latest software and network standards.

C. The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, network controllers and operator devices, while re-using existing controls equipment.

D. In order to meet these requirements, the BMS must be capable of many methods of integration, at each tier of the network:

1. First Tier Network:

   a. The first tier network shall be based on a PC industry standard of Ethernet TCP/IP. PC Workstation LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels, and shall be capable of communicating over all industry standard media types.

   b. The first tier network shall provide communications between operator workstations and first tier network controllers.

   c. The first tier network will be compatible with other facility-wide networks. The first tier shall be capable of being connected to a facility network by way of standard networking practices.

   d. The primary communication bus shall be installed so that a break in any bus does not affect the communications operation of the bus.

2. Second Tier Network

   a. The second tier network shall be based on an industry standard open protocol communication method.

   b. The second tier network shall provide communications between Intelligent Building Equipment and first tier network controllers.

3. Integration: The ability of control system components from different manufacturers to connect together and provide coordinated control. Integration shall extend to the operator's workstation software, which shall support user interaction with all control system components. Methods of integration include industry standard protocols such as: BACnet, LonMark/LonTalk, OLE for Process Control (OPC) or integrator interfaces between cooperating manufacturer's systems.

a. Open protocol integration.

1) Original Equipment Manufacturer's (OEM) may provide connectivity by adopting the BMS manufacturer's protocol for their product. OEM devices include but are not limited to chillers, boilers, variable frequency drives, power monitoring system, and medical gas.

b. BACnet Protocol Integration

1) The protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-1995. Supported media shall include fiber, 10base2, and 10baseT.

2) A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

3) The network shall conform to BACnet conformance class 4, and provide the ability to monitor and control BACnet system points from the BMS.

c. Industrial Protocol Integration

1) Industrial Standard protocols such as Allen-Bradley Data Highway, Modbus+, or Eurotherm-LIN, and others shall be capable of integrating with the BMS.
2) The MNI software and hardware, in conjunction with the integrated systems, shall translate data from multiple systems into one system and one user interface. The MNI shall allow an operator to monitor and control data and systems through an Operator Workstation (OWS).

d. OPC (OLE for Process Control) Integration

1) Operator Workstations shall utilize an OPC client/server architecture so that real-time data can be passed between other OPC compliant systems.

e. Echelon LON WORKS protocol.

1) LonMark certified controllers communicating over LonTalk networks shall interface with the BMS by connection to the network controller, operator workstation, or first tier network.

f. Hardwired

1) Analog and digital signal values shall be passed from one system to another via hardwired connections.

E. The BMS is required to interact with equipment such as chillers or boilers that are provided by other trades. The BMS Contractor shall furnish appropriate equipment and connections to properly integrate these devices. The specific method of integration and the compatible equipment manufacturers shall be stipulated in the BMS Contractor's proposal, and submittals. It is the responsibility of the General Contractor to ensure that compatible equipment is provided.

2.3 OPERATOR INTERFACE

A. Personal Computer Operator Workstation Hardware

1. Provide (1) workstation located in the 1st floor maintenance office. Location shall be confirmed with Owner.

2. Personal computer operator workstation(s) shall be provided for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.

3. Each workstation shall consist of the following, at a minimum:

a. Full tower case personal computer with the latest Pentium processor, 128 MB RAM, 10 GB hard drive and controller, 3-l/2" diskette drive, read/write CD ROM drive, 2 GB MB internal tape drive, mouse and 101-key enhanced keyboard.

b. Color monitor with SVGA display and a diagonal screen measurement of no less than seventeen inches (17"). Separate controls shall be provided for color, contrasts and brightness. The screen shall be non-reflective. Minimum resolution of 1280 x 1024, .26 or better dot pitch and 72 Hz minimum vertical refresh rate or maximum resolution. 65k colors.

4. Provide a color printer at one (1) workstation for printing of critical alarms, operator transactions, system repots, and any other screen displays. The owner shall choose the workstation to be connected to the color printer. The printer shall have the following requirements at a minimum:

a. Color laser jet with 2400 x 1200 dpi resolution.

b. 32K Buffer to store complete graphics for printing.

B. Personal Computer Operator Workstation Software

1. General

a. Provide software which includes the following:

1) Scheduling and override of building operations.

2) Collection and analysis of historical data.

3) Editing, programming, storage and downloading of controller databases, programs, and parameters.

b. A 32-bit, multi-tasking Microsoft Windows NT or Windows 2000 environment that allows the user to run several applications simultaneously. Other Windows applications shall run simultaneously with the BMS software including but not limited to Word, Excel, Access, etc.

c. Provide a user interface that shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection.

d. Operator specific password access protection shall allow the user to limit workstation control, display and data base manipulation capabilities for each object in the system. An object shall be defined as any input or output point, setpoint, system program, etc. The operator privileges shall “follow” the operator to any workstation or Primary Control Panel that the operator logs on to. Provide a minimum of 200 passwords.

e. Operators will be able to perform only those commands on the objects available based on their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.

f. An audit trail report to track system object changes which shall record operator initiated actions. These actions shall include, but not be limited to, changes made by a particular person, changes made to a specific piece of equipment, and/or changes made during a designated time frame. The changes shall be printed and archived for future reference either on command or automatically, at the operator’s option. The operator activity tracking data shall be stored in a tamper proof buffer.

g. Software shall allow the operator to perform commands including, but not limited to:

1) Start up and shutdown of equipment.

2) Setpoint adjustment.

3) Add/modify/delete time programming.

4) Enable/disable process execution.

5) Lock/unlock alarm reporting.

6) Enable/disable totalization and/or trending.

7) Override PID loop setpoints.

8) Enter temporary override schedules.

9) Define holiday schedules.

10) Change time/date.

11) Automatic daylight savings time adjustments.

12) Enter/modify analog warning and alarm limits.

2. Reporting

a. Reports shall be generated and directed to either CRT displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:

1) A general listing of all points in the network

2) List of all points currently in alarm

3) List of all points currently in override status

4) List of all disabled points

5) List of all points currently locked out

6) DDC Controller trend overflow warning

7) List all weekly schedules

3. Scheduling

a. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide schedules for 365 days in advance.

b. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.

c. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.

4. Collection and Analysis of Historical Data

a. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. Any system point may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data shall be stored on hard disk for future diagnostics and reporting.

b. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred directly to an off-the-shelf spreadsheet package such as Excel. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.

c. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both historical and/or real-time dynamic point data. A minimum of 10 points shall be viewed simultaneously on a single graph. The user may pause the graph and take "snapshots" of screens to be stored on the hard disk for future recall and analysis. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.

1) Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.

2) Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

5. Dynamic Color Graphic Displays

a. All workstation(s) shall be provided with color graphics. All workstation(s) software shall include a graphical viewing and control environment and definition and construction of dynamic color graphic displays.

b. Provide system color graphics for each HVAC system and for each electrical, plumbing and/or piping system that is monitored and/or controlled by the BMS Provide scaled floor plans indicating equipment location, service, and system data as required.

c. Provide color graphic floor plan displays and system schematics for each piece of mechanical equipment, including but not limited to air handling units, chilled water systems and hot water systems to optimize system performance analysis and speed alarm recognition.

d. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.

e. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.

f. The windowing environment of the PC operator workstation(s)shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.

g. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays via an off the shelf graphics package similar to MicroGraphix Designer.

1) Provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.

2) Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility.

h. Provide an automatically updated, dynamic display of the site-specific BMS architecture indicating the status of primary and secondary controllers, PC workstation(s) and networks.

i. Provide a separate dynamic display page of each HVAC (AHU, AC, chiller, cooling tower, fuel oil, etc.), electrical, and/or plumbing system connected to the BMS.

j. Provide a separate dynamic display page of each piece of terminal equipment (VAV box, fan coil unit, etc.) connected to the BMS.

k. Provide an additional (10) separate dynamic, graphic display pages at each workstation as required by the operating staff to further assist in daily system operations.

l. Graphics shall incorporate all system integration points communicated via hardware or software gateways and/or interfaces. Origin of information shall be transparent to the operator and shall be controlled, displayed, trended, etc. as if the points were hardwired to the BMS.

6. System Configuration and Definition

7. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

a. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently add, delete or modify any system object including Primary Control Panel(s), operator workstations(s), Secondary Control Panels, reporting definitions, control loops, energy management applications, time and calendar-based programming, totalization, historical data trending, custom control processes, graphic displays, operator passwords, alarm messages, etc.

b. Definition of operator device characteristics for individual points, applications and control sequences shall be performed using instructive prompting software.

1) Programming shall be performed with the BMS system online and shall not interfere with BMS system operation.

2) Inputs and outputs for any process shall not be restricted to a single Primary Control Panel, but shall be able to include data from any and all other network panels to allow the development of network-wide control strategies. Processes shall also allow the operator to use the results of one process as the input to any number of other processes (cascading).

3) Provide the capability to backup and store all system databases on the workstation hard disk. In addition, all database changes shall be performed while the workstation(s) are on-line without disrupting other system operations. Changes shall be automatically recorded and downloaded to the appropriate Primary Control Panel.

Similarly, changes made at the Primary Control Panels shall be automatically uploaded to the workstation, ensuring system continuity. The user shall also have the option to selectively download changes as desired.

4) Provide context-sensitive help menus to provide instructions appropriate with operations and applications currently being performed.

C. Telecommunication Capability:

1. Provide all hardware and software to allow operators at dial-up workstation(s) the ability to perform all BMS operator workstation functions as specified herein.

2. Auto-dial/auto-answer communications shall be provided to allow any part of the BMS to communicate with remote operator workstations and/or remote terminals on an intermittent basis via voice-grade telephone lines. Auto-dial Primary Control Panels shall automatically place calls to workstations to report alarms or other significant events.

3. DDC Controllers shall be able to store a minimum of 10 phone numbers of at least 20 digits. Retry a single primary number at a fixed interval until successful.

4. The auto-dial program shall include provisions for handling busy signals, "no answers" and incomplete data transfers. Provide as a minimum 3 secondary numbers when communications cannot be established with the primary device.

5. Operators at dial-up workstations shall be able to perform all control functions, all report functions and all database generation and modification functions as described for workstations connected via the network. Routines shall be provided to automatically answer calls from remote Primary Control Panels. The fact that communications are taking place with remote Primary Control Panels over telephone lines shall be completely transparent to an operator.

6. An operator shall be able to access remote buildings by selection of any facility by its logical name. The workstation dial-up program shall store the phone numbers of each remote site, so the user shall not be required to remember or manually dial telephone numbers.

7. A PC workstation may serve as an operator device on a network, as well as a dial-up workstation for multiple auto-dial Primary Control Panels or networks. Alarm and data file transfers handled via dial-up transactions shall not interfere with network activity nor shall network activity keep the workstation from handling incoming calls.

8. Dial-up communications shall make use of Hayes compatible modems and voice-grade telephone lines. Provide modems rated at 28,800 BPS.

D. Web Based Operator Interface:

1. A graphical interface shall be provided that allows customers to access modify, and control the BMS data and operation via the Internet or Intranet. This interface shall use HTML-based pages to send and receive data from a BMS system to a web browser.

2. The software shall run on the Microsoft Internet Explorer (5.0 or higher) and the Netscape (4.0 or higher) browsers.

3. The interface shall provide four levels of user access. Users will range from read-only access to BMS data (level 4) to having complete access to view and modify BMS data and user accounts (level 1).

4. The interface shall provide a user account utility, complete with a user profile database that includes user ID, encrypted password, access level, and language preference. Operators with the appropriate access level shall be able to add, modify, and delete users within the user profile database, as well as change users' access levels.

5. The interface shall provide a means by which the user can collect items (BMS data points) into "summary" groups. This functionality shall allow authorized users to perform actions ranging from viewing summary groups, to adding items to or deleting items from groups, to creating new summary groups.

6. The web-based interface shall provide the following four screens (or views) and the indicated functionality for each:

   a. Logon screen – allows the user to enter his or her user name and password for logging into the system.

   b. System view – which provides a browser to view the available OPC servers and the branches of information (BMS data points) registered within each.

   c. Summary view – allows the user to view items that have been grouped together into summaries, and allows authorized users to modify or delete groups or items within a group.

   d. User Account view – displays a list of the currently defined users and the corresponding user information. Users with level 2 access can change their passwords. Users with level 1 access can also modify and delete other users' information.

   e. The interface shall provide navigation tools for moving between the System, Summary, and User Account views. In addition, it shall provide tools for gaining access to help and for logging out of the system.

E. Portable Operator's Terminal

1. Provide one (1) portable operator's terminal(s).

2. The POT shall be hand-held and plug directly into individual Primary and Secondary control panels as described below. Provide a user-friendly, English language-prompted interface for quick access to system information.

3. Functionality of the portable operator's terminal connected at any Primary Control Panel:

a. Logon to system using same operator passwords utilized with PC operator workstation(s) and/or remote modem(s).

b. Access all network information from Primary Control Panels, if authorized by password level.

c. Display all point, selected point, and alarm point summaries.

d. Display all trending and totalization information.

e. Add, modify, and/or delete any existing or new system point.

f. Command, change setpoint, enable/disable any system point.

g. Acknowledge all alarms.

h. Connect to local logging and report printer.

4. Simultaneous connection of all POTs to any control panel shall not:

a. Interrupt or interfere with normal network operation in any way.

b. Prevent alarms from being transmitted.

c. Preclude any centrally-initiated commands and/or system modification.

2.4 PRIMARY CONTROLLER

A. Primary Control Panel Hardware

1. Spare Capacity

a. All Primary Control Panels shall be installed with spare points (minimum 2 of each type) and spare memory capacity for future connections. Provide all hardware software, processors, power supplies, communication controllers, etc. required to ensure adding a point to the spare point location only requires the addition of the appropriate sensor/actuator and field wiring/tubing.

b. Provide all necessary hardware for a complete operating system as required. All hardware shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

c. Each Primary Control Panel shall, at a minimum, be provided with:

1) Appropriate NEMA rated enclosure.

2) A stand-alone, multi-tasking, multi-user, real-time digital control microprocessor module.

3) Primary Network communication module, if needed for primary network communications.

4) Secondary Network communication module, if needed for secondary network communications.

5) Memory module to accommodate all Primary Control Panel software requirements, including but not limited to, its own operating system and databases, including control processes, energy management applications, alarm management applications, historical/trend data for points specified, maintenance support applications, custom processes, operator I/O, dial-up communications.

6) Data collection/ Data Trend capability.

7) Power supplies as required for all associated modules, sensors, actuators, etc.

8) Input/output point modules as required including spare capacity.

9) Software modules as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

10) A portable printer connection port.

11) A portable operator terminal connection port to allow the temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

12) Monitoring of all industry standard types of analog and digital inputs and outputs.

13) Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

d. Each Primary Control Panel shall continuously perform self-diagnostics on all hardware and network communications.

e. Each Primary Control Panel shall provide battery backup to support the real-time clock and all memory and programs for a minimum of 1hours. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPS's) of sufficient capabilities for all controllers, panels and operator work station(s).

f. Each Primary Control Panel shall support firmware upgrades without the need to replace hardware.

g. Each controller shall support its associated secondary network(s).

h. Primary control panels shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. Primary control panels shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems, printers or terminals.

i. Isolation shall be provided at all primary control panel terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.

2. Primary Control Panel Software

a. Provide all necessary software for a complete operating system as required. All software shall reside in each Primary Control Panel. Primary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

b. All points, panels and programs shall be identified by a point descriptor. The same names shall be displayed at both the Primary Control Panel(s) (via portable terminal, printer or modem) and the PC operator workstation(s). In addition to the point's descriptor and the time and date, the user shall be able to print, display or store an alarm message to more fully describe the alarm condition or direct operator response. Alarm messages shall be coordinated with the Owner.

c. All digital points shall have a user-defined, two-state status indication.

d. Each Primary Control Panel shall, at a minimum, be provided with software for:

1) Two-position control, proportional control, proportional plus integral control, proportional, integral, plus derivative control algorithms, all with automatic control loop tuning.

2) Limiting the number of times each piece of equipment may be cycled within any one-hour period.

3) The system shall provide protection against excessive demand situations during start-up periods by automatically introducing time delays between successive start commands to heavy electrical loads. Upon the resumption of power, each DDC Controller shall analyze the status of all controlled equipment, compare it with normal occupancy scheduling and turn equipment on or off as necessary to resume normal operations.

4) Priority load shedding.

5) Energy management routines including time of day scheduling, calendar-based scheduling, holiday scheduling, temporary schedule overrides, start-stop time optimization, automatic daylight savings time switch over, night setback control, enthalpy switch over, peak demand limiting, temperature-compensated duty cycling, heating / cooling interlock, supply temperature reset, priority load shedding, and power failure restart.

6) Custom, job-specific processes defined by the user, to automatically perform calculations and special control routines and sequences of operations.

   (a) It shall be possible to use any system measured point data or status, any system calculated data, a result from any process or any user-defined constant in any controller in the system.

   (b) Any process shall be able to issue commands to points in any and all other controllers in the system.

   (c) Processes shall be able to generate operator messages and advisories to other operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a printer or pager.

   (d) The custom control programming feature shall be documented via English language descriptors.

7) Generate and receive automatic and manual operator messages and advisories.

8) Interactive HELP function to assist operators connected via POTs and modems.

9) Comment lines for all programs.

10) Distributed, independent alarm analysis and filtering. Reporting of selected alarms during system shutdown and start-up shall be automatically inhibited. A minimum of six priority levels shall be provided for each point.

11) Automatically accumulate and store run-time hours for all digital points.

12) Automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and pulse input type points.

e. Trend data shall be stored at the Primary Control Panels and automatically uploaded to the PC workstation. All trend data shall be available for use in any 3rd party personal computer applications located in the BMS

f. Primary Control Panels shall be able to assign password access and control priorities. The logon password (at any PC workstation(s)or portable operator terminal) shall enable the operator to monitor, adjust and/or control only the systems, programs, primary control panel, and/or secondary control panels that the operator is authorized for. Passwords and priority shall be fully programmable and adjustable.

g. Primary Control Panels shall be able to access any data from, or send control commands and alarm reports directly to, any other Primary Control Panel or combination of controllers on the network without dependence upon a central or intermediate processing device. Primary Control Panels shall also be able to send alarm reports to multiple operator workstations without dependence upon a central or intermediate processing device.

h. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Controller shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the DDC Controllers ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.

1) All alarm or point change reports shall include the point's English language description and the time and date of occurrence.

2) The user shall be able to define the specific system reaction for each point. Alarms shall be prioritized to minimize nuisance reporting and to speed operator response to critical alarms. Priority levels shall be provided for each point. Point priority levels shall be combined with user definable destination categories (PC, printer, DDC Controller, etc.) to provide full flexibility in defining the handling of system

alarms. Each DDC Controller shall automatically inhibit the reporting of selected alarms during system shutdown and start-up. Users shall have the ability to manually inhibit alarm reporting for each point.

3) Alarm reports and messages will be directed to a user-defined list of operator devices or PC's.

4) In addition to the point's descriptor and the time and date, the user shall be able to print, display or store the alarm message to more fully describe the alarm condition or direct operator response.

5) Each DDC Controller shall be capable of storing a library of at least 50 alarm messages. Each message may be assignable to any number of points in the Controller.

i. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points.

1) DDC Controllers shall store point history data for selected analog and digital inputs and outputs:

(a) Any point, physical or calculated may be designated for trending. Any point, regardless of physical location in the network, may be collected and stored in each DDC Controllers point group. Two methods of collection shall be allowed: either by a pre-defined time interval or upon a pre-defined change of value. Sample intervals of l minute to 7 days shall be provided.

(b) Trend data shall be stored at the DDC Controllers and automatically uploaded to the workstation. Uploads shall occur based upon user-defined interval, manual command or automatically. All trend data shall be available for use in any 3rd party personal computer applications.

(c) DDC Controllers shall also provide high resolution sampling capability for verification of control loop performance.

j. DDC Controllers shall automatically accumulate and store run-time hours for all digital input and output points.

k. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis for all analog and digital pulse input type points.

l. DDC Controllers shall count events such as the number of times a pump or fan system is cycled on and off. Event totalization shall be performed on a daily, weekly and monthly basis for all points

2.5 SECONDARY CONTROLLER

A. Secondary Control Panel Hardware

1. Each Secondary Control Panel shall operate as a stand-alone controller capable of performing its user selectable control routines independently of any other controller in the system. Each secondary control panel shall be a microprocessor-based, multi-tasking, real-time digital control processor.

2. Provide a Secondary Control Panel for each of the following types of equipment (if applicable):

   a. Constant Air Volume (CAV) boxes

   b. Duct-mounted reheat coils

   c. Fancoil Units

   d. Fan-Powered Variable Air Volume (VAV) Boxes
   e. Reheat Coils

   f. Supplemental AC units

   g. Variable Air Volume (VAV) Boxes

   h. Ventilation fans.

   i. Other terminal equipment

3. Each Secondary Control Panel shall, at a minimum, be provided with:

   a. Appropriate NEMA rated enclosure.

   b. A stand-alone real-time digital control microprocessor module.

   c. Secondary network communications ability.

   d. Power supplies as required for all associated modules, sensors, actuators, etc.

   e. Input/output points as required.

   f. Software as required for all sequences of operation, logic sequences and energy management routines. Relay logic is not acceptable.

   g. Auxiliary enclosure for analog output transducers, isolation relays, etc. Auxiliary enclosure shall be part of primary enclosure or mounted adjacent primary enclosure.

   h. Each controller measuring air volume shall include a differential pressure transducer.

   i. SCR control of electric heaters.

j. Fan speed controller for fan powered VAV boxes

k. Fan relay for fan powered VAV boxes and fan coil units

4. Each Secondary Control Panel shall continuously perform self-diagnostics on all hardware and secondary network communications. The Secondary Control Panel shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failure to establish communication to the system.

5. Provide each secondary control panel with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM, EPROM and PROM, or a minimum of 1-hour battery backup shall be provided. The controllers shall be able to return to full normal operation without user intervention after a power failure of unlimited duration. Provide uninterruptible power supplies (UPSs) of sufficient capacities for all terminal controllers that do not meet this protection requirement. Operating programs shall be field-selectable for specific applications. In addition, specific applications may be modified to meet the user's exact control strategy requirements, allowing for additional system flexibility. Controllers that require factory changes of all applications are not acceptable.

6. The secondary control panels shall be powered from a 24 VAC source provided by this contractor and shall function normally under an operating range of +/- 10%, allowing for power source fluctuations and voltage drops. The controllers shall also function normally under ambient conditions of 32 to 122 F (0 to 50 C) and 10% to 90% RH (non-condensing). Provide each controller with a suitable cover or enclosure to protect the intelligence board assembly.

B. Secondary Control Panel Software

1. Provide all necessary software for a complete operating system as required. All software shall reside in each Secondary Control Panel. Secondary Control Panels shall not be dependent upon any higher level computer or another controller for operation.

2. Each secondary controller shall perform its primary control function independent of primary controller LAN communication, or if LAN communication is interrupted. Reversion to a fail-safe mode of operation during LAN interruption is not acceptable. The controller shall receive its real-time data from the primary control panel time clock to insure LAN continuity. Each controller shall include algorithms incorporating proportional and integral (PI) control for all applications. All PI parameters shall be field-adjustable by the user via a portable operator’s terminal.

3. Secondary control panels shall support pressure independent terminal boxes including VAV cooling only, VAV with hot water or electric reheat,

Fan-powered VAV and Fan-powered VAV with hot water or electric reheat. All VAV box control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units to perform the specified sequences of control. This requirement must be met in order to allow for future design and application changes and to facilitate system expansions. Controllers that require factory application changes are not acceptable.

2.6 INPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.

2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

3. All sensor signals shall be via a 4-20 ma loop.

B. Analog Inputs

1. Temperature Sensors (Not Including Space Temperature Sensors)

a. All temperature sensors shall use RTD (Resistance Temperature Detector) elements. All control signals shall be via a 4-20 ma loop.

b. Calibration adjustments: Zero & Span.

c. Any point, physical or calculated may be designated for trending.

d. Provide Minco or equal.

e. Range:

1)	Liquid Immersion Temperature F	+20/+120 F, +70/+220
2)	Duct (Single Point) Temperature F	+20/+120 F, +70/+220
3)	Duct (Averaging) Temperature	+20/+120 F
4)	Outside Air Temperature	-50/+122 F

2. Space Temperature Sensors

a. RTD or thermistor type

b. Accuracy: ±0.5 F

c. Operating Range: 80 Degree Range Maximum

d. Setpoint Adjustment Range: 55 to 95 F

e. Shall include a terminal jack integral to the sensor assembly to allow the operator to query and modify operating parameters of the local room terminal unit from the portable operator's terminal.

f. Concealed setpoint adjustment switch with software limits.

g. Push-button override switch. The override switch may be locked out, overridden, or limited as to time through software by an authorized operator.

h. Room sensors shall not be located on outside walls.

i. The length of wiring from the space temperature sensor to the controller shall not exceed 100 ft.

3. Humidity Sensors

a. All control signals shall be via a 4-20 ma loop.

b.	Sensor Range:	0 to 100%
c.	Accuracy:	±2% RH
d.	Sensing element:	Capacitive sensor
e.	Operating Temperature:	15F to 170F
f.	Supply Voltage:	12 – 36 VDC

g. Provide Hycal or equal

4. Dewpoint Sensors

a.	Accuracy:	± 2.0 Fdp
b.	Range:	-40/+115 F DP

5. Water Differential Pressure Sensor

a. Provide industrial grade sensors for all differential pressure bypass valves.

b. Factory calibrated for operating range.

c. Rated for system pressure.

d. Manufacturers standard 316 stainless steel.

e. 3 valve manifold and pressure gauges for supply and return pressures.

f. Output shall be 4-20 ma.

g. Rosemount 1151DP, with 316 stainless steel or approved equal.

6. Differential Pressure Transmitter

a. Sensor

1) Accuracy: 5% at 400 to 4000 FPM (2 to 20.4 m/s)

2) Range: 0 to 4000 FPM (0 to 20.4 m/s)

7. Static Pressure Sensor

a. Accuracy: 1% full scale.

b. Transmitter: 4-20mA.

c. Range shall be as required by application.

d. Provide Setra or equal.

8. Airflow Measuring Stations

a. Station

1) Airflow measuring stations required to accomplish the specified control sequence shall be furnished under this section but installed under the sheet metal section. Airflow measuring stations shall be of heavy gauge metal construction, and shall be furnished with an air straightening section with an open face area of not less than 97%.

2) Each airflow measuring station shall measure airflow by means of a network of static and total pressure sensors factory positioned and connected in parallel to produce an averaged velocity pressure. The measured velocity pressure converted to airflow (CFM) shall have an accuracy of 2% of the full scale throughout the velocity range from 700 to 4,000 FPM when measured under ideal laboratory conditions. The location of stations shall meet manufacturer's guidelines.

3) The maximum resistance to airflow shall not exceed 0.6 times the velocity head. The unit shall be suitable to withstand temperatures up to 250F.

4) All interconnecting tubing between the air measuring and any remote metering or control shall be furnished and installed by the supplier of the station. A minimum of one static and one total pressure sensor shall be used for every 16 sq. inches of duct cross sectional area for ducts up to four sq.ft. in cross section. For larger ducts, a minimum of one static and one total pressure sensor shall be used for every 36 sq. inches of duct cross sectional area.

5) Interconnecting sensor manifolds shall equalize and relate each type of sensor measurement into one total pressure and one static pressure metering port. The permanent system pressure loss created by the unit shall not exceed .15 of a velocity head. Each airflow measuring station shall consist of 16-gauge sheet metal casing and an air straightening section with an open face area not less than 97%. The sheet metal contractor shall install air measuring stations.

6) Provide Air Monitor Fan-E or equal with an accuracy of ± 2%, a turndown of 6 to 1, and no pressure loss across the station.

7) Final locations to be coordinated with sheet-metal contractor and manufacturer to ensure installed actual accuracy meets specifications.

b. Velocity Pressure Sensor For Airflow Measuring Stations

1) Range: 0.1 to 0.5"wg (Size based on ABMS Output).

2) Accuracy: ± 0.25" W.G.

3) Transmitter: 4 – 20 ma.

9. Analog Water Level Sensors

a. Furnish and install full height, analog level sensors for each location as specified. Sensor shall provide 4-20ma signal in proportion to basin water level. Provide waterproof enclosure and mounting hardware as required.

b. Sensor shall be Drexel Brook or equal.

10. Flow Meters

a. Provide insertion type, turbine flow meters designed to mount through a fully open, 1 inch full bore ball valve supplied by flow meter manufacturer. Meter flow range shall be 2-40 feet/second for liquid service. Meter linearity shall be +/-1% for a 10:1 range. Repeatability shall be 0.10%. Turbine head and stem shall be constructed of stainless steel, bearings shall be tungsten carbide, and housing and flange shall be carbon steel. Housing pressure rating shall be 350 PSI. A D.C. powered, two-wire transmitter shall be mounted on the flow meter. The flow transmitter output shall be a 4-20 madc signal that is linear with flow. Transmitter input shall be from magnetic pickup. Transmitter accuracy shall be 0.25% of span.

b. Provide an isolation valve kit for turbine flow meters, including isolation valve, bypass valve, nipple, etc., to allow service and removal under pressure and while system is operating.

c. Turbine meter shall be Onicon F 1220 or equal.

11. Carbon Dioxide Sensor

    a. The carbon dioxide detectors shall be catalytic-bead type with a demonstrated resistance to silicones and reduced sulfur compounds. Detectors shall have a typical life span of three years. The sensors shall have a dual housing with the sensor and transmitter in separate housings, with sensors located up to 50 feet from the transmitter. Housings shall be explosion proof for Class 1, Group B, C and D, Division 1 areas. Input power shall be 250ma at 24VDC. Response time shall be less than 5 seconds to final reading, from a step change in gas concentration. Sensor/transmitter repeatability shall be +/- 1% full scale. Transmitter signal shall be 4-20 ma.

    b. The detection system shall be MSA model 487817 or equal.

    c. Provide a calibration kit (flow system type) including zero gas and test carbon dioxide gas. Turn over complete kit to owner at warranty start date.

    d. Power 24VDC power supply as required from Emergency source.

12. Carbon Monoxide Monitoring and Control System

    a. The sensor/transmitter shall be the MSA model 212376 with a range of 0-200 PPM full scale, or equal.

    b. The sensor/transmitter shall incorporate a solid-state, semi-conductor type sensor offering a minimum useful life span of 8 years.

    c. The sensor/transmitter shall be 3-wire, 4-20 ma design and shall operate on 24Vdc. The output of the unit shall be linearized to the full scale range.

    d. The transmitter circuitry shall include full temperature and humidity compensation and shall incorporate a purge cycle to periodically heat the semiconductor to a high temperature to allow recovery from iterferent gases and high CO concentrations.

    e. The response time of the unit, accounting for the purge cycle, shall be 150 seconds or less to 90% of a step change in CO level.

    f. The sensor unit shall be provided with a suitable Nema enclosure for wall mounting in loading dock area and garage area.

    g. Provide a green LED for power on, a red LED for sensor failure, a yellow LED for CO warning level reached and a red LED for CO alarm level reached. LEDs shall be visible from the outside of the unit enclosure.

    h. Provide a calibration kit (flow system type) including zero gas and test gas. Turn over complete kit to owner at warranty start date.

i. Power 24VDC power supply as required from Emergency source.

j. Provide one sensor/transmitter per 5,000 square feet of parking garage and loading dock.

13. Outside Air Volume Sensor/Controller

a. Provide an outside airflow measuring and control system utilizing DDC controls as required by the plans and specifications. System shall be designed to provide accurate measurement without upstream and downstream ductwork.

b. Outside airflow measuring and control system shall have a velocity range from 45 ft/min to 6000 ft/min with a minimum accuracy of 5.0%. Each sensor in the array shall be independently processed for velocity value.

c. Provide 0-10 VDC or 4-20 ma signal proportional to velocity to Control Panel. Control Panel shall modulate damper to maintain setpoint.

d. Provide Dybec, Ruskin or equal.

C. Binary Inputs

1. Water Differential Pressure Switches

a.	Range:	8 to 70 PSI
b.	Differential:	3 PSI
c.	Maximum differential pressure:	200 PSI
d.	Maximum pressure:	325 PSI

e. Provide Mercoid or equal

f. Shall be used for all pump status specified in the point schedule.

2. Air Differential Pressure Switches

a. Diaphragm type.

b. Die-cast aluminum housing.

c. Adjustable setpoint.

d. Switch rating shall be a minimum of 5 amps at 120 VAC.

e. Switches shall be SPDT.

f. The switch pressure range shall be suited for the application.

g. Provide Dwyer or equal.

3. Freezestats

a. Furnish and install, for each air handling unit with outdoor air connections, a low temperature safety thermostat (freezestat) with a 20 ft. sensing element.

b. There shall be one freezestat per coil section.

c. Element shall be installed in a serpentine fashion across the inlet of the cooling coil in the air stream.

d. Element shall be arranged to stop the unit supply fan and its associated return air fan should the temperature at any point along the sensing element fall below 35°F for an adjustable time period.

e. Low temperature detector shall be automatic reset, DPDT type.

f. Provide manual reset button at primary control panel and time delay relay to lockout fan if freeze condition exists for more than 60 seconds. Time delay relay shall be adjustable up to 5 minutes.

4. Current Sensing Relay

a. Provide and install current sensing relays for all motor status points 5HP and greater. Sensor shall be split core, two wire, loop powered and sized for expected amperage. Unit shall be UL listed. Provide status LEDs for current sensed below setpoint, current sensed above setpoint and loop power failure. The unit shall automatically range itself and have solid state outputs.

D. Miscellaneous Monitoring Systems

1. Energy Metering System

a. Provide energy (chilled, and hot water) electric metering, reporting and tracking system including all meters, sensor and software. The system shall record, store and report energy consumption, integral to the BMS operator workstation(s)software. The software shall be Excel spreadsheet based, and operate in a Windows environment.

b. For all water flow meters, provide supply and return temperature sensors for "Delta-T" calculation of BTU consumption. Monitor total accumulated BTUs, current BTUs, monthly total BTUs, and yearly total BTUs for each location specified or shown. Provide flow meters at main system lines and each air-handling unit coil.

c. 3P/4W Watt Transducer

1) Provide transducer as required. Input signal shall be a maximum of 0-480 Volts and 0-1000 Amps with a corresponding output of 4-20 ma. Sensor shall be sized to be mid-scale amperage at normal conditions. Response time shall be a maximum of 250 sec with an accuracy of +/-

0.5% full scale. The unit shall be field calibratable and be as manufactured by Kele or equal.

d. Current Transformer

1) Provide transducer as required. Input signal shall be a maximum of 0-1000 Amps with a corresponding output of 0-5 Volts. Sensor shall be sized to be mid scale amperage at normal conditions. Response time shall be a maximum of 250 msec with an accuracy of +/- 0.5% full scale. The unit shall be split core and as manufactured by Crompton, or equal.

2. Fuel Oil Meters

a. Provide fuel oil flow meter on fuel oil supply for duplex fuel oil pump set. Meters shall be contacting head type approved for use in fuel oil systems. Monitor total accumulated flow, current flow, monthly total flow, and yearly total flow for each duplex pump set and jockey pump specified or shown.

b. Meter shall be intrinsically safe, explosion proof with a minimum resolution of 10 gallons with G.P.M. range appropriate for application.

3. Water Leak Detection System

a. General

1) Furnish and install a complete water detection system for each area specified. The system shall include electronic alarm and locating modules, sensing cable, graphic maps and all auxiliary equipment. The system shall simultaneously detect the presence of water at any point along the cable's length, sound an alarm, and pinpoint the distance to the leak. The sensing cable shall be of such construction that no metallic parts shall be exposed to the environment. The system shall provide pre-connecterized sensing cable and components. The system shall be UL listed and FM approved.

2) The water leak detection system shall be installed in the following areas: (Add locations for water leak detection system).

3) The system shall be as manufactured by Raychem Corporation or equal.

4) Provide two sets of test instrumentation to owner.

b. Locating leak detection panel (TTB-FA)

1) The alarm and locator module, TTB-FA, shall monitor up to a maximum of 1000 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm, actuating an output relay, sending a proportional 4-20 ma signal to the BMS and displaying the distance from the start of the sensing cable to the start of the first contact with water. The location of the first water contact shall be retained on the display until the cable is dry and the module is updated.

2) The alarm module shall be capable of detecting the presence of a 1 inch leak any where along the cable with a repeatability of +/- 1%.

3) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

4) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow). The module shall be equipped with exposed test, reset and silence buttons. All other functions shall require key access.

5) The alarm module shall be powered by emergency power.

6) The module enclosure shall be a minimum of 16 gauge steel, flush mounting type.

c. Single point leak detector

1) The alarm module, TTC, shall monitor up to a maximum of 50 feet of sensing cable. The alarm module shall indicate that water has contacted the sensing cable by sounding an audible alarm and actuating an output relay. The relay shall remain activated until the cable is dry and the module is reset.

2) The alarm module shall be capable of detecting the presence of a 1 inch leak anywhere along the cable with a repeatability of +/- 1%.

3) The alarm module shall continuously monitor the sensing cables and interconnecting cables for continuity. Any break in the cable shall generate an audible alarm, activate an output relay and activate a "continuity" LED on the face of the module.

4) The alarm module shall have LED's indicating "power" (green), "alarm" (red) and "continuity" (yellow).

5) The alarm module shall be powered by emergency power.

6) The module shall be mounted in a field equipment cabinet.

d. Jumper cable

1) Jumper cable shall be used where leak detection cable is not required but continuity is required (in raceways between alarm module and floor surface, etc.). The jumper cable shall be plenum-rated and jacketed with fluoropolymer materials, as per NEC 725-2(b). The jumper cable shall consist of four different color (Y, B, R, G), insulated 18 AWG wires and shall be available in pre-connectorized lengths of 5, 10, 15, 25 and 50 feet.

e. Accessories

1) Provide all end connectors, leader cables, hold down clips, caution tags, spray adhesive (3M 90M) as required.

f. Graphic display map

1) Provide a graphic display map for each room served. The map shall be a 1/8 in = 1.0 ft scaled drawing of the area served, indicating actual equipment locations, floor tile and other points of reference. The actual cable routing shall be clearly marked on the map with actual scaled distances every 10 feet.

2) A dynamic graphic display, equivalent to the aforementioned map, shall be duplicated on the BMS operator workstation. The area in alarm (within 5 feet) shall blink in red until the alarm is cleared.

g. Performance

1) A maximum wetted area of 2 inches of cable, at any point along the entire length of cable, shall activate an alarm.

2) The system shall be continuously monitored for continuity. The loss of continuity shall cause an alarm within 5 seconds.

3) The cable shall be capable of being cleaned with a clean dry cloth, in place.

4) The cable shall dry and reset the module immediately upon removal from free water. No shaking, wiping or mechanical action shall be required.

h. Installation

1) All system components shall be installed in accordance with the manufacturer's recommendations. The manufacturer shall provide necessary installer training and supervision as required.

2) The cable shall be installed on clean, dry finished surfaces only (coordinate access and schedule installation as required) after the possibility of physical damage has been eliminated. The cable shall be fastened to the surface it is monitoring every 4 feet with hold down clips and spray mastic adhesive. Hold down clip installation shall be subject to spot checks during commissioning. If any clip fails, all other clips shall be re-attached and re-tested, at no additional cost.

3) The system shall be commissioned prior to acceptance. Submit a test procedure for approval.

i. Warranty

1) All equipment shall be warranted to the same extent as the BMS system, or per the manufacturer's warranty, whichever is greater.

4. Audio/Visual Alarm Units

a. Provide audio/visual alarm unit(s) that shall be located in each of (2) mechanical rooms, maintenance office, loading dock, and operation center. Verify locations with owner.

b. Each audio/visual alarm unit shall include a 1" x 3" translucent illuminated rectangular alarm blue color light ("BMS Alarm"), a Sonalert horn (hidden), a silence switch with stainless steel cover plate to match mounting surface. When any BMS alarm occurs (as coordinated with facilities personnel), the alarm light shall flash once per second (adjustable) and the horn shall sound. When the silence switch is pushed, the horn will silence and the pilot light shall light continuously until alarm is cleared.

c. The BMS shall monitor the alarm light, horn and silence switch status.

d. Provide 1/8 inch high engraved and painted lettering for operational instructions as required by the owner on the cover plate.

2.7 OUTPUT DEVICES

A. General

1. All devices and equipment shall be approved for installation.

2. Provide the following field devices as required by the monitoring, control and optimization functions listed elsewhere in this specification.

B. Actuation

1. Electric-Only Actuation

a. All valve actuation shall be electric. Pneumatic actuation is not acceptable.

2. Electric Actuation

a. All valve and damper actuation shall be pneumatic except for terminal equipment valves and dampers which shall be electric. Terminal equipment includes:

1) Cabinet Unit Heaters

2) Constant Air Volume (CAV) boxes

3) Duct-mounted reheat coils

4) Fancoil Units

5) Fan-Powered Variable Air Volume (VAV) Boxes

6) Radiation

7) Supplemental AC units

8) Unit Heaters

9) Variable Air Volume (VAV) boxes

3. Incremental Electronic Actuator for Terminal Equipment Valve and/or Damper Actuation.

a. Incremental actuators shall be allowed for terminal equipment only.

b. Actuators shall be proportional, electronic, direct-coupled actuators used for modulating service. Actuators shall be equipped with metal housings and visual stroke indicators.

c. Actuators shall be equipped with a permanent manual adjustment.

d. Minimum Torque: 35 in-lb.

e. Operating Voltage: 24 VAC.

f. Input Signal: 3 wire floating, 0 – 10 VDC, or 4 – 20 ma.

g. Frequency: 50, 60 Hz.

h. Power Consumption: 1.5va maximum.

i. Spring Return Time: 20 seconds maximum.

j. Nominal Force: 90 lb. Minimum.

k. Stroke: 7/32" (5.5 mm) maximum.

l. For use when the maximum media temperature is 230° F.

4. Valve Actuation

a. All valve actuators shall be sized to close against a differential pressure greater than 125% of the design pump head. Where pressure and flow combinations exceed ratings for commercial valves and actuators, industrial class valves and actuators shall be provided.

b. Valve actuators shall provide smooth modulation at design flow and pressure conditions.

c. Valve actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

1)	Air-Handling Unit Preheat Valves	Normally Open
2)	Air-Handling Unit Cooling Valves	Normally Closed
3)	Air-Handling Unit Heating Valves	Normally Open
4)	Duct-mounted Reheat Coil Valves	Normally Closed
5)	All Humidification Valves	Normally Closed
6)	Radiation Valves	Normally Open
7)	Unit Heater Valves	Normally Open
8)	Cabinet Unit Heater Valves	Normally Open

d. **Electronic Modulating Actuator for Valves 2" and Smaller**

1) Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.

2) Actuators shall be equipped with a clutch release for manual override and visual and electronic stroke indicators.

3) Operating Voltage: 24 VAC.

4) Input Signal: 4 - 20 ma.

5) Power Consumption: 18 VA maximum.

6) Spring Return Time: 15 seconds maximum.

7) Nominal Force: 225 lb. Minimum.

8) Stroke: 3/4" (20 mm) maximum.
9) For use when the maximum media temperature is 300 F.

e. **Electronic Modulating Actuator for Valves 2-1/2" and Larger**

1) Actuator shall have electronic, proportional control and shall be direct-coupled with spring return.

2) Actuators shall be equipped with a clutch release for manual override and visual and electronic stroke indicators.

3) Operating Voltage: 24 VAC.

4) Input Signal: 4 - 20 ma.

5) Power Consumption: 28va maximum.

6) Spring Return Time: 20 seconds maximum.

7) Nominal Force: 610 lb.

8) Stroke: 1-1/2" (40 mm) maximum.

9) For use when the maximum media temperature is 300° F.

f. Provide emergency power service to all heating valve actuators.

5. Damper Actuation

a. Damper actuators shall have external adjustable stops to limit the stroke in either direction.

b. All damper actuators shall have sufficient power to overcome friction of damper linkage and air pressure acting on louvers and to operate the damper smoothly throughout the entire damper range.

c. Actuators shall be sized with a torque greater than 150% of the design damper torque.

d. Actuators shall have mounting arrangement for location outside of the air stream. The damper actuators shall be mounted on the damper extension so that it is not burned in the wall construction.

e. Damper actuators shall fail-safe in either the normally open or normally closed position in the event of power failure, signal failure or compressed air failure. Fail Safe Positions are as follows:

1)	Outside Air Dampers	Normally Closed
2)	Return Air Dampers	Normally Opened
3)	Exhaust Air Dampers	Normally Closed
4)	F/SM, SM Dampers	Normally Closed

f. **Electric Damper Actuation for Modulating and Two Position Damper Actuation**

1) Provide proportional, electronic, direct-coupled spring return actuators for all automatic dampers used for modulating service. Each actuator shall be equipped with a brushless DC motor, self centering shaft coupling, metal housing, permanent manual override, visual stroke indicators, built in adjustable start and span controls, and shall be sized to operate the damper with a torque greater than 150% of the design damper torque. Provide actuators with the following specifications:

(a)	Operating Voltage:	24 VAC
(b)	Input Signal: (two position)	4-20 ma (modulating), on/off
(c)	Frequency:	50, 60 Hz
(d)	Power Consumption:	9 VA Maximum
(e)	Spring Return Time:	15 seconds Maximum
(f)	Minimum Torque:	144 in-LB
(g)	Angular Rotation:	90 Degrees

g. Provide emergency power source main air-handling unit and network room damper actuators.

h. Fire/Smoke Damper Actuation

1) Actuator shall be manufactured and factory-installed by the fire/smoke damper manufacturer.

2) Acceptable manufacturers: Ruskin, Imperial or approved equal.

3) Provide emergency power source.

2.8 CONTROL VALVES

A. General

1. All automatic control valves controlled by the central control system (/BMS) shall be furnished by the controls contractor unless noted otherwise in these documents.

2. All automatic control valves shall be installed by the mechanical trade.

3. **The controls contractor shall provide wiring as follows:**

   a. All line voltage power for electric valve actuators shall be wired by the controls contractor from the nearest available power panel. Coordinate with electrical trade.

   b. All wiring between the central control system (ATC/BMS) and the valve actuator shall be wired by the controls contractor.

   c. All wiring between the valve actuator and their associated thermostats, pressure switches, control devices, etc. shall be wired by the controls contractor.

   d. All wiring shall comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

B. Hot Water / Chilled Water Control Valves

1. Single-seated.

2. Fully proportioning with modulating plug or V-port inner valves.

3. Body pressure rating and connection type construction shall conform to fitting and valve schedules. The ANSI rating of the valve shall match the ANSI rating of the piping in which the valve is installed. Minimum ANSI rating shall be ANSI 125.

4. Stainless steel stems and trim.

5. Spring loaded Teflon packing with replaceable discs.

6. Quiet in operation.

7. Fail-safe in either normally open or normally closed position in the event of power failure.

8. Capable of operating in sequence with other valves and/or dampers when required by the sequence of operation.

9. Capable of operating at varying rates of speed to correspond to the exact dictates of the controller and variable load requirements.

10. Sized by the control manufacturer and guaranteed to meet the heating and cooling loads as scheduled.
11. Shall be suitable for the pressure conditions and shall be sized to close against 125% of the design pump head.

12. No single valve shall be larger than 2-1/2". Whenever the flow rate is such as to require a valve larger than 2-1/2", then two valves in parallel shall be used, with no one larger than 2-1/2". The valves shall operate sequentially.

13. Where pressure and flow combinations exceed ratings for commercial valves and operators, industrial class valves and operators shall be provided. Control valves shall be sized for a 5 PSI pressure drop at full flow.

C. Differential Pressure Control Valves

1. Provide for all water systems where modulating water flow conditions are required to prevent excessive pump pressure build-up. Provide a valve for each chilled and hot water system. Valve to be globe type. Provide valves 2" and smaller with screwed end bodies and provide valves 2-1/2" and larger with flanged ends.

D. Butterfly Valves

1. Furnish automatic butterfly valves for isolation requirements as shown on the drawings or required herein.

2. Butterfly valves shall be have body ratings in accordance with the piping specifications.

3. Valves shall be high performance, fully lugged with carbon steel body ANSI 300 as required by pipe specifications.

4. Valves shall be bubble tight with 316 stainless steel disc, stainless steel shaft and reinforced Teflon seat.

5. If electric actuation is utilized, actuators shall be fail in place with factory mounted open and closed position limit switches mounted.

6. Provide fail in place, electric actuators with waterproof enclosure and crankcase heater for actuator and accessories mounted outside.

7. Provide manual override hand wheels for each valve.

8. Valves shall be Jamesbury 830L or equal.

9. Butterfly valves will only be approved for cooling tower bypass and all two-position (open or close) applications.

10. Valves must have lug type body connections.

2.9 DAMPERS

A. Automatically Controlled Dampers

1. Temperature control manufacturer shall provide all actuated dampers which do not have either a fire and/or smoke rating and shall comply with the following:

   a. Dampers shall be of the louver type with neoprene or vinyl edged blades and end seals.

   b. Louver blades shall be #16 gauge galvanized steel, maximum 8" in width.

   c. Frames shall be minimum 4" reinforced flat galvanized steel with welded corners and stiffening and provisions for end seals.

   d. All rods shall be non-corrosive material with provision for positive interlocking of blades and actuators on the shaft.

   e. Where local codes require fire dampers on outside air intakes, rods shall not be of aluminum construction.

   f. All bearings shall be nylon or Teflon.

   g. All hardware shall be of non-corrosive material.

   h. Two position dampers may be of the parallel-blade type. Modulating dampers shall be of the opposed-blade type.

   i. Provide solid stops on all sides of the frames against which the louver shall close in order to provide maximum 2% leakage at 5" static pressure.

   j. Automatic damper actuators shall be limited to a minimum of one every sixty square feet for two-position type and one every forty square feet for modulating type.

   k. Damper actuators shall meet the same requirements as valve actuators with respect to operating at variable rates of speed, etc., and shall have external adjustable stops to limit the stroke in either direction.

   l. All damper actuators shall be of the neoprene or rubber diaphragm piston type, with sufficient power to overcome friction of damper linkage and air pressure acting on louvers and with mounting arrangement for location outside of the air stream, wherever possible.

B. Fire/Smoke Dampers

1. Dampers shown on drawings designated as "F/SM" shall comply with the following:

a. All fire/smoke dampers shall have a UL label.

b. Dampers shall be provided with factory-installed, UL-rated full sleeves.

c. Provide airfoil or "V" Blade damper blades supported with shafts and stainless steel bearings to allow daily operation.

d. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems and when closed shall be the equivalent of a 1 ½ hour fire damper.

e. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G.

f. The damper manufacturer shall provide damper actuators.

g. All dampers shall be provided with position indicator switches to enable remote status of open or closed positions, however, only those dampers designated in the plans and specifications as F/SM (HS), which indicate that they will be controlled from a central fire command station will be wired for remote status and remote open/closed operation. This central fire command shall provide additional and overriding control of all F/SD's and SD's, which shall also be controllable via central BMS. F/SD and SD f ire control panel shall be by this contractor and located per plans. Control panel shall also include start/stop/starters of all fans (with associated control dampers. This contractor is responsible for coordination and relay interlock of BMS and remote fire control panel with building fire alarm system.

h. Dampers that are controlled from a central fire command station shall:

1) Be provided with a 212°F heat sensor with normally closed contacts (manual reset) to close and lock damper if open.

2) Additionally, dampers shall be factory-equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F. to 350°F., depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station.

3) The following will be accepted in lieu of the two firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150°F or less.

4) Dampers that are not controlled from a central fire command station shall have a fusible link that melts on heat causing damper to close and lock in a closed position.

C. Smoke Dampers

1. Dampers shown on drawings designated as "SM" shall comply with the following:

a. All fire/smoke dampers shall have a UL label.

b. Dampers shall be provided with factory-installed, UL-rated full sleeves.

c. Provide airfoil or "V" Blade damper blades supported with shafts and stainless steel bearings to allow daily operation.

d. Provide intermediate supports and bearings for damper blades more than 36" long. They shall conform to UL Standard 555 and 555S as leakage rated dampers in smoke control systems and when closed shall be the equivalent of a 1 ½ hour fire damper.

e. Leakage shall conform to Class 2 with maximum leakage of 10 CFM/Sq. Ft. at 1" W.G.

f. The damper manufacturer shall provide damper actuators. If dampers are pneumatically actuated, the damper manufacturer shall provide EP switch.

g. All dampers shall be provided with position indicator switches to enable remote status of open or closed positions, however, only those dampers designated in the plans and specifications as F/SM (HS), which indicate that they will be controlled from a central fire command station will be wired for remote status and remote open/closed operation.

h. Dampers that are controlled from a central fire command station shall:

1) Be factory-equipped with a second normally closed heat sensor correlating to the operator/actuator degradation temperature classification (250°F. to 350°F., depending on actuator utilized). The second sensor is wired through a manual override switch on the central fire command station.

2) The following will be accepted in lieu of the two firestats described. A resettable bimetallic link which opens on heat permitting damper to close and lock if open. This link may be re-engaged from fire command station at temperature of 150°F or less.

D. Installation

1. General

a. All electric operated dampers which have a fire and/or smoke rating shall be furnished by the mechanical contractor. All other electric operated dampers shall be furnished by this Contractor. All dampers shall be installed by the mechanical contractor.

b. The BMS contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The controls contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

c. The Mechanical contractor shall furnish damper actuators for all dampers that he furnishes. Where practical, actuators shall be factory mounted by the damper manufacturer. The mechanical contractor shall provide a terminal strip along side the damper for all dampers he furnishes.

d. Wiring for motor operated dampers that do not have a fire and/or smoke rating shall be provided by the controls contractor from the damper actuator and any associated end switches and sensors to a terminal strip that is wall mounted along side the damper.

e. The controls contractor shall provide wiring as follows:

1) Between the central control system BMS and the terminal strip for all dampers monitored and/or controlled by the BMS whether or not the controls contractor has furnished the damper.

2) Between the terminal strip for all dampers and their associated thermostats, pressure switches, etc. whether or not the control contractor has furnished the damper.

f. Dampers incorporating multiple sections shall be controlled in unison. Where more than one (1) actuator serves a damper, then the actuators shall be driven in unison and the control wiring shall be provided accordingly.

g. Dampers incorporating multiple sections shall be designed in such a way that the actuators are easily accessible. Under no circumstances shall it be necessary to remove damper sections or structural or other fixtures to facilitate removal of damper motors. Provide access doors wherever necessary to meet this requirement. In particular, insure that where in-air stream actuators are provided, they are readily accessible.

h. The BMS contractor shall provide all power and control wiring for all automatic, fire/smoke or smoke dampers as required to accomplish the HVAC and smoke control sequences of operation. A portion of

this work may also be specified in other areas of the specification. It is the responsibility of the BMS contractor to coordinate this work with the other trades. Any work not performed by others will be the ultimate responsibility of the BMS contractor. The fire alarm system shall be able to open or close each damper, regardless of BMS commands.

i. The following table summarizes the trade responsibilities with respect to automatic dampers:

	Non-Fire or Smoke Rated Dampers	Fire and/or Smoke Rated Dampers Not Controlled by Fire Alarm System	Fire and/or Smoke rated Dampers Controlled by Fire Alarm System
Furnish Damper	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Damper	Mechanical Trade	Mechanical Trade	Mechanical Trade
Furnish Actuators(s)	Controls Contractor	Mechanical Trade	Mechanical Trade
Install Actuator(s)	Mechanical Trade	Mechanical Trade	Mechanical Trade
Install and furnish terminal strip complete with all relays, wiring, etc.	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring between actuator, end switches, heat terminal strip.	Controls Contractor	Mechanical Trade	Mechanical Trade
Provide wiring from central control system (BMS) to damper terminal strip.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from FAS to damper terminal strip.			Electrical Trade
Furnish 120V main power to electric actuators (see notes below)	Controls Contractor	Controls Contractor	Electrical Trade
Provide wiring from damper terminal strip to terminal strips for interlocked motors, etc.	Controls Contractor	Controls Contractor	Controls Contractor
Provide wiring from damper terminal strip directly to thermostats, etc.	Controls Contractor	Controls Contractor	Controls Contractor

NOTES

1. Controls contractor shall have overall responsibility for the complete coordination of the work and the operation of the damper/actuator installation.

2. Provide 120V control power circuits an emergency distribution board for all equipment designated for service under emergency power (see Electrical Drawings). Equipment includes, but is not limited to, all F/SD's, SD's, and associated controllers and control panels. This contractor is responsible for coordinated emergency power circuits with electrician. These circuits will be terminated in a junction box located in each associated mechanical room and shall be used by the controls contractor to supply local control panels and critical equipment.

   These circuits will also be used by the electrical trade to supply dampers, etc. , requiring control by the Fire Alarm System. Final connection from the terminal strips to the actuators, end switches and sensors shall be by the mechanical trade.

   For dampers not requiring control by the fire alarm system and for other non-critical equipment, obtain power from either the emergency circuits as detailed above or from the motor starter terminal trip. All wiring shall be by the controls contractor.

   2. Damper Terminal Strips

      a. Terminal strip(s) shall be provided along side all motorized dampers. If the damper has a smoke and/or fire rating, the terminal strip shall be provided by the Mechanical Trade. If the damper does not have a fire and/or smoke rating then the terminal strip shall be provided by the controls contractor.

      b. Where dampers are furnished by the controls contractor then he shall provide relays, interconnect wiring and other components to meet the requirements detailed below. The terminal strip(s), relays, etc. shall be housed in wall mounted enclosures which meet the specifications detailed for local starter enclosures.

      c. The terminal strip shall be wired such that the Central Control System (BMS) can undertake the following control and monitoring functions:

         1) Open Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across these terminals the damper is driven open. If the damper is two position with an actuator which drives closed and springs open on loss of power then these terminals shall not be used. This signal from the Central Control System (BMS) shall be overridden by a close signal from the Fire Alarm System (FAS) Where dampers are interlocked to motors then the wiring shall be to these terminals.

         2) Close Control - A pair of terminals shall be wired such that when a controls (BMS) relay closes a contact pair across

these terminals the damper is driven closed. If the damper is two position with an actuator which drives open and springs closed on loss of power then these terminals shall not be used. This signal from the Central Control System (BMS) shall be overridden by an open signal from the FAS.

3) Motor Interlock - A pair of terminals shall be wired to an end switch on the actuator such that the contacts between the terminals shall be closed when the damper is fully open and open when the damper is not fully open. This pair of terminals shall be used for interlocking a damper with a motor such that the motor will not be able to start if the damper is not fully open.

3. Purge Dampers

a. For each damper which is to be monitored and/or controlled by the Fire Alarm System (FAS), the damper actuator, heat sensor and end switches shall each be wired by the mechanical trade to a terminal strip(s) mounted adjacent to the damper so that the FAS can undertake the following control and monitoring functions:

1) FAS “Open/Close” Control - The damper will be driven open in response to closure of an FAS relay contact and will spring closed in response to opening of this relay contact.

2) FAS “Override Open” Control (Smoke Purge Dampers Only) - The damper will be re-opened, subsequent to a heat sensor initiated closure, in response to closure of a second FAS relay contact (or re-closure of the first contact for single sensor dampers).

3) FAS “Open/Closed” Status Monitoring Control (Smoke Purge Dampers Only) - End Switch closures will cause activation of FAS “opened” and “closed” relays in response to operation of end switches at both ends of travel.

4) FAS “Override of (BMS)” Control - For each damper requiring both FAS and ATC (BMS) control, the Controls Contractor shall mount an interface relay within 30 circuiting feet of the damper terminal strip, so wired as to permit FAS override of the ATC (BMS) control.

b. The controls contractor’s damper manufacturer shall provide all necessary wiring diagrams to the FAS contractors.

c. Dampers furnished by the mechanical trade shall have similar terminal strips to which the controls contractor shall wire where necessary.

d. Comply with code requirements. Segregate high and low voltage wiring & circuits and segregate the FAS and controls (BMS) terminals.

2.10 CONTROL PANELS

A. Field Equipment Cabinets

1. All DDC controllers, transformers, electric relays, static pressure sensors, velocity pressure sensors, manual override switches, etc., shall be mounted in an appropriate NEMA enclosure and factory wired to terminal strips. The enclosure shall be constructed of steel or extruded aluminum and shall be properly rated for the location. Securely mount the enclosures to the wall or floor of the building structure using approved bracing adjacent to each system to be controlled.

2. Cabinets shall allow extra space for installation of future control components.

3. Submit for approval all proposed locations of DDC control and accessory panels.

4. Submit for approval dimensioned shop drawings of the panel equipment layout prior to panel fabrication.

5. Properly label all panel components including wiring and tubing.

B. Air Dryer System

1. Provide in parallel (2) refrigerated air dryers for the compressed air system at each location, one piped as a standby. Each unit shall consist of a hermetically sealed, direct connected refrigerant compressor and motor unit, automatic drain valve, non-toxic refrigerant, automatic expansion valve, condenser, lubrication system insulation, and other items and accessories, contained in a wall mounted cabinet. The air dryers shall be connected in to the high-pressure side of the compressed air line with copper tubing between the air tank and the pressure reducing station. Each unit shall be non-cycling type, with sufficient capacity to chill the compressed air output of one compressor, to a dewpoint of 35 degrees F with an inlet air temperature of 100EF air (based on 110F ambient temperature) required for normal temperature control system operation. Air dryers shall be piped with manual bypass.

2. Provide a compressed air pressure reducing station complete with two (2) air filters, two (2) oil filters, reducing valves, safety valves, isolating valves, gauges, brass piping and fittings. The use of type K copper tubing with brass or copper solder joint fittings is also acceptable for assembling this station. The reducing station shall be wall mounted adjacent to the air compressor and in each MER. Equipment and piping shall be arranged to provide identical parallel paths for the compressed air to be discharged to the temperature control system at the reduced pressure required for the mode of operation.

3. Provide a replaceable media cartridge type particulate and oil filters in the air piping between the refrigerated dryer and the pressure reducing station. Filters shall be so designed that the media can be replaced without removing the entire unit from the piping. A drain, with valve or petcock, shall be provided at the bottom of the filter assembly. Provide, per air pressure reducing station, two (2) pre-filters and two (2) oil filters, each sized for the compressed air requirements. Filters shall provide a dirt and oil free system. Isolation and changeover valves shall permit uninterrupted service during maintenance.

4. Provide 2 pressure reducing valve parallel branches, each branch having a minimum of three, _? pressure reducing valves. These valves shall reduce the air pressure, in stages, from 80 PSI to 30 PSI to 19psi to 15psi. (these pressures are nominal and may differ from manufacturer to manufacturer)

5. Provide high pressure (80 PSI) to each MER.

6. Provide an approved make ASME standard bronze safety valve at the air tank and after each pressure reducing valve. The safety valve at the air tank shall be 3/4?, set at 80 PSI and each safety valve after the primary reducing valve shall be _?, set at 38 PSI. Safety valves after the other pressure reducing valves shall be _?, set approximately 5 PSI higher then the setting of the reducing valve it follows. Safety valves shall be Crosby Valve & Gauge Co., Kunkle Valve Co. or J.E. Lonergan Co.

7. Provide compressed air system sized for system requirements plus 50% spare capacity.

C. Air Gauges

1. Provide air pressure gauges on all main compressed air systems including, main station, air filters, pressure reducing valves, etc. Gauges shall be 2-1/2" in diameter, minimum.

2. Provide air pressure gauges on controlled equipment compressed air signals. Gauges shall be 1-1/2" in diameter, minimum.

D. Pressure Reducing Stations

1. Provide dual pressure reducing stations in each MER. Station shall incorporate air filters, gauges, manual valves and pressure reducing valves to provide low pressure air as required. Station shall be piped to provide 100% standby and be valved to allow maintenance without compressed air shut down.

2.11 NON BMS DEVICES

A. Non-BMS Monitored Devices

1. Electric Thermostats

a. Furnish and install all line voltage thermostats for unit heaters, cabinet unit heaters, and/or radiation. Thermostat contacts shall be rated for maximum heater amperage and shall be snap acting, SPDT.

b. Thermostat shall have a concealed setpoint adjustment.
c. Thermostat shall have concealed thermometer temperature indication.

2. Aquastats

a. Furnish and install strap on aquastats to prevent unit heaters from operating when hot water is not available.

PART 3 - EXECUTION

3.1 DESIGN CRITERIA

A. The Building Management System (BMS) shall be programmed to start and stop the HVAC equipment based on occupancy schedules as coordinated with the owner. The BMS shall also provide equipment interlocks as required.

B. Static pressure safeties shall not be overridden during smoke purge, but other safeties (freezestats) shall be overridden.

C. Each preheat coil section shall be provided with a separate sensor, control loop, output signal, freezestat, and control valve.

D. All control valves that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

E. All control dampers that are sequenced shall be provided with dedicated analog outputs or positioning relays, as applicable.

F. Fire Alarm Interface for Fans

1. The Fire Alarm System shall provide outputs to notify the BMS of fire alarms.

2. All fan systems shall be stopped from the FAS. When the fan system stops, all associated dampers shall close.

3. All return and exhaust fans shall be stopped from the FAS. When the fan stops, all associated dampers shall close.

4. BMS fire control panel shall provide override and start/stop/status of fans (with associated control dampers), F/SD's and SD's as set forth in section 2.9 herein.

G. All safeties shall be capable of being remotely reset from the BMS.

H. All setpoints shall be adjustable from any BMS personal computer operator workstation via single point commands.

I. All reset schedule parameters shall be adjustable from any BMS personal computer operator workstation via single point commands.

J. All inputs and outputs shall be provided with programmable (adjustable) high and low software alarm limits.

3.2 INSTALLATION CRITERIA

A. Space mounted devices are to be identical in appearance. All devices shall be mounted under the same style cover.

B. Room sensors and thermostats shall not be located on outside walls.

C. Provide all relays, switches, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system in accordance with the sequences specified.

D. Install controls so that adjustments and calibrations can be readily made. Controls are to be installed by the control equipment manufacturer.

E. Mount surface-mounted control devices, tubing and raceways on brackets to clear the final finished surface on insulation.

F. Conceal control conduit and wiring in all spaces except in the Mechanical Equipment Rooms and in unfinished spaces. Install in parallel banks with all changes in directions made at 90 degree angles.

G. Install control valves horizontally with the power unit up. Installation of control valves will be by the mechanical contractor.

H. Unless otherwise noted, install wall-mounted sensors, thermostats and humidistats to meet ADA requirements. Submit device samples, locations, mounting heights and details for approval for all devices.

I. Install outdoor thermostats in perforated tube and sun shield.

J. All relays, electrical wiring, panels, outputs, etc. to make a complete operational system, shall be provided and installed by this section. See sequences of operation for details.

K. All device locations in finished spaces shall be verified with Architect.

L. Component Tags

1. All automatic and manual valves provided by this contractor, shall be identified with 2" diameter brass tags and brass chains. Lettering shall be ½" high, stamped and painted black. Automatic valve tags shall be stamped with the letters "AV" and sequentially numbered. Provide valve schedule and sample tags for approval.

2. All sensors shall be identified with 1"x 3" black labels with white lettering. Lettering shall be 1/4" high. Provide sensor number, HVAC Unit number, part number and sensor range on tag. Submit tag schedule and sample for approval.

3. All panels, auxiliary component panels, transformer panels, etc. provided by this contractor, shall be identified with 2"x 5" black lamacoid labels with engraved white lettering. Lettering shall be ½" high. Provide panel number, HVAC unit number and service on tag. Submit tag schedule and sample for approval.

3.3 ELECTRICAL WIRING

A. The BMS Contractor shall be responsible for all electrical control work associated with the BMS, HVAC and plumbing systems which is not specified as work of others.

1. Perform all wiring in accordance with all local and national codes including the NEC.

2. Install all line voltage wiring, concealed or exposed, in conduit in accordance with the Division 16 specifications, NEC and local building code.

3. All low voltage electrical control wiring and all Primary Network wiring throughout the building shall be run in conduit. Terminal equipment sensors and the secondary network wiring may be run in plenum rated cable above accessible hung ceilings. Plenum cable shall be run parallel to building lines and supported from the building structure (not from duct, pipe or associated hangers) with bridle rings.

4. Provide extension of 120 volt, 20 amp circuits and circuit breakers from emergency power panels for entire system, except terminal equipment, as required.

5. Surge transient protection shall be incorporated in the design of system to protect electrical components in all DDC control panels and operator workstations.

6. Provide all miscellaneous field device mounting and interconnecting control wiring for all mechanical systems including but not limited to the fuel oil system, emergency generators, chillers, water treatment, AC units, condensing units, PIMs, cooling towers, expansion tanks, VFDs, unit heaters, filtration systems (air and water), terminal units, fan coil units, electric heaters, house tanks, chiller control system, kitchen equipment, fans, H&V, cabinet heaters, hot water heater, ejectors, sump pits, domestic water system, steam PRV stations, underground pipe leak detection system, and plumbing systems.

7. All systems requiring interconnecting control wiring as specified herein, shall have hardwired interlocks and shall not rely on the BMS to operate (e.g. emergency generator to fuel oil pump interlock, emergency generator to ventilation damper, etc.). Interconnecting wiring shall be run in conduits separate from the BMS associated wiring.

8. All wiring for network communication, sensor signals and interlock wiring shall be permanently labeled at a minimum of 10-foot intervals. Label shall indicate BMS manufacturer's name and cable usage. Labels shall be securely fastened and not be damaged during installation. Cable jackets shall also be color coded to indicate application.

9. Cables shall be tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass.

10. All control and power wiring associated with the control of all automatic, fire/smoke or smoke dampers shall be installed in conduit, regardless of voltage. All control and power wiring for relays associated with the control of any automatic, fire/smoke or smoke damper shall be installed in conduit, regardless of voltage.

11. Data communication between separate buildings or facilities shall be via fiber optic cable only.

12. Provide all line and low voltage wiring for the control of all HVAC, plumbing and fire protection motors (whether individual or as part of packaged equipment) and dampers, including wiring for EP's, PE's, relays, control panels, unit heater and cabinet heater control, etc., <u>except as noted</u> <u>below</u>. Provide wiring to interface devices (relays or others) located within 3 feet of each damper requiring direct smoke and fire control by the Fire Protective Alarm (FPA) System in addition to its automatic temperature control operation.

    a. A separate system of wiring, for smoke and fire control of motors which are to be automatically and/or manually controlled by the fire protective alarm (FPA) system will be run to the motor starters or SCU enclosures by the electrical trade.

    b. Wiring, for smoke and fire control of dampers which are to be automatically and/or manually controlled directly by the FPA system (i.e., not in response to motor operation) will be run by the electrical trade. Wiring will include connections to an adequate 120 volt emergency source, and to interface relays provided as part of the automatic temperature control work within 10 feet of each such damper which is also to be controlled as part of the automatic temperature control work.

13. The BMS contractor shall provide wiring:

    a. Between thermostats, aquastats and unit heater motors.

    b. All control and alarm wiring for all control and alarm devices for all Sections of Specifications.

    c. 120 volt, single phase, 60 hertz emergency power to every BMS panel, VAV box controller, BMS console, PIM, CRT, CPU, valve transmission power supplies, annunciator modules, modems, intercom modules, printers and to other devices as required. It is the intent that the entire building management system and all peripheral devices, alarms, etc., shall be operative under emergency power conditions in the building. The power supplies are to be extended in conduit and wire from emergency circuit breakers.

    d. Provide power supply wiring (as required) to all dampers which do not require “direct” (i.e., not in response to motor operation) smoke and fire control by the fire protective alarm (FPA) system.

    e. Provide status function conduit and wiring for equipment covered under this section.

f. Provide conduit and wiring between the BMS panels and the temperature, humidity, or pressure sensing elements, including low voltage control wiring.

g. Provide conduit and control wiring for devices specified in this Section.

h. Provide conduit and signal wiring between motor starters in motor control centers and high and/or low temperature relay contacts and remote relays in BMS panels located in the vicinity of motor control centers.

i. Provide conduit and wiring between the PC workstation, electrical panels, metering instrumentation, indicating devices, miscellaneous alarm points, remotely operated contractors, and BMS panels, as shown on the drawings or as specified.

j. Provide electrical wall box and conduit sleeve for all wall mounted devices.

k. Firestopping shall be provided for all penetrations of conduit, etc. through fire rated walls and floors and other fire rated separations.

l. Where conduit is required, it shall be steel electric metallic tubing (EMT), except that it shall be galvanized intermediate steel conduit where located within 8'-0" of the floor in mechanical spaces (or is otherwise exposed to mechanical damage), or is intended for embodiment in concrete.

14. Wires and cables shall have characteristics - in compliance with Articles 725 and/or 800 (as applicable) of the National Electrical Code - as described elsewhere in the specifications or drawings for this project, and shall be UL listed in accordance therewith.

15. Where wires and cables are permitted to be run without conduit, they shall be independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables shall not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor shall they be supported from pipes, ducts or conduits. Where cables are bundled together, separate bundles shall be provided separately for each type of cabling and separately for each independent system. Bundling and/or supporting ties shall be of a type suitable for use in a ceiling air handling plenum regardless of whether or not installed in a plenum.

16. Utilize #14 A.W.G. THWN conductors minimum throughout for power wiring (120 VAC or greater) except in conjunction with a manual starter. For a manual starter, utilize conductors equal in size to those in the power circuit.

17. Motor control circuit wires may be run in the same conduit as the wires of motor power circuits; however, abide by the following:

a. Exclude motor control wires from enclosures (other than motor starter enclosures) which contain power circuit overcurrent protection and switching devices;

b. Exclude motor control wires from pull boxes and junction boxes containing the wires of main and submain feeders.

c. Utilize auxiliary pull boxes to separate motor control wires from motor power circuit wires at a point before the power circuit wires enter the items from which motor control wires are excluded.

d. Exclude motor control wires from the same conduits as motor power circuit wires larger than 250 MCM.

18. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

a. Wires and Cables:

1) American Insulated Wire Corporation, Leviton Manufacturing Co.

2) Brand-Rex Cable Systems, Brintec Corp.

3) Carol Cable Company, Inc.

4) Senator Wire & Cable Co.

5) Southwire Co.

6) Belden Division, Cooper Industries

7) Cable & Wire Division, A.T.& T.

8) American Insulation Wire Company.

b. Connectors for Wires and Cables:

1) AFC, Monogram Co.

2) AMP, Inc.

3) Anderson, Square D Co.

4) Electrical Products Division, 3M Co.

5) O-Z/Gedney Unit, General Signal.

c. Connectors and Splices

1) UL-listed factory-fabricated wiring connectors of size, ampacity rating, material, and type and class for application and for service indicated.

19. Examine raceways and building finishes to receive wires and cables for compliance with installation tolerances and other conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

20. Utilize copper conductors with THWN, THHN or XHHW insulation. Type THHW and THHW-2 shall not be utilized where excluded by conduit sizing. Type THWN shall not be utilized for connection to 100% rated overcurrent devices.

21. Pull conductors into raceway simultaneously where more than one is being installed in same raceway.

22. Use pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation.

23. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.

24. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

25. Properly ground all field equipment panels and terminal unit equipment.

3.4 COORDINATION

A. Coordination with Other Trades

1. Piping and duct installation requirements are specified in other Division 15 Sections. Coordinate installation of all devices furnished under this section to be installed by other trades with the appropriate trade.

2. It is the responsibility of this contractor to coordinate with all trades the location of installed equipment and routing of all electrical and pneumatic control conduits and lines.

3. Install control system components to allow for proper service and maintenance of equipment.

B. Work Performance Schedule

1. A time-phased schedule for delivery, installation, and acceptance of components for the complete system shall be prepared. Submit this schedule to the Owner within five (5) days after award of contract. Submit updates and changes to this schedule promptly to the Owner.

3.5 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.

B. Commissioning, Testing and Acceptance

1. Perform a three-phase commissioning procedure consisting of field I/O calibration and commissioning, system commissioning and integrated system program commissioning. Document all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Commissioning work that requires shutdown of system or deviation from normal function shall be performed when the operation of the system is not required. The commissioning must be coordinated with the owner and construction manager to ensure systems are available when needed. Notify the operating personal in writing of the testing schedule so that authorized personnel from the owner and construction manager are present throughout the commissioning procedure.

2. Phase I – Field I/O Calibration and Commissioning

   a. Verify that each control panel has been installed according to plans, specifications and approved shop drawings. Calibrate, test, and have signed off each control sensor and device. Commissioning to include, but not be limited to:

      1) Sensor accuracy at 10, 50 and 90% of range.

      2) Sensor range.

      3) Verify analog limit and binary alarm reporting.

      4) Point value reporting.

      5) Binary alarm and switch settings.

      6) Actuator and positioner spring ranges if pneumatic actuation is utilized.

      7) Fail safe operation on loss of control signal, pneumatic air, electric power, network communications, etc.

3. Phase II – System Commissioning

   a. Each BMS program shall be put on line and commissioned. The contractor shall, in the presence of the owner and construction manager, demonstrate each programmed sequence of operation and compare the results in writing. In addition, each control loop shall be tested to verify proper response and stable control, within specified accuracy. System program test results shall be recorded on commissioning data sheets and submitted for record. Any discrepancies between the specification and the actual performance will be immediately rectified and re-tested.

4. Phase III - Integrated System Program Commissioning

   a. Tests shall include, but not be limited to:

      1) Data communication, both normal and failure modes.

2) Fully loaded system response time.

3) Impact of component failures on system performance and system operation.

4) Time/Date changes.

5) End of month/ end of year operation.

6) Season changeover.

7) Global application programs and point sharing.

8) System backup and reloading.

9) System status displays.

10) Diagnostic functions.

11) Power failure routines.

12) Battery backup.

13) Smoke Control, vents, in concert with Fire Alarm System testing.

14) Testing of all electrical and HVAC systems with other division of work.

b. Test procedure and documentation shall be as follows:

1) Submit for approval, a detailed acceptance test procedure designed to demonstrate compliance with contractual requirements. This Acceptance test procedure will take place after the commissioning procedure but before final acceptance, to verify that sensors and control devices maintain specified accuracy and the system performance does not degrade over time.

2) Using the commissioning test data sheets, the contractor shall demonstrate each point. The contractor shall also demonstrate 100 percent of the system functions. The contractor shall demonstrate all points and system functions until all devices and functions meet specification.

3) The BMS contractor shall supply all instruments for testing. Instruments shall be turned over to the owner after acceptance testing.

4) All test instruments shall be submitted for approval prior to their use in commissioning.

5) Test Instrument Accuracy:

a) Temperature: 1/4F or 1/2% full scale, whichever is less.

b) High Pressure (PSI): ½ PSI or 1/2% full scale, whichever is less.

c) Low Pressure: 1/2% of full scale (in w.c.)

d) Humidity: 2% RH

e) Electrical: 1/4% full scale

6) After the above tests are complete and the system is demonstrated to be functioning as specified, a thirty-day performance test period shall begin. If the system performs as specified throughout the test period, requiring only routine maintenance, the system shall be accepted. If the system fails during the test, and cannot be fully corrected within eight hours, the owner may request that performance tests be repeated.

c. Sub Systems shall also be tested and commissioned.

5. Move In Checkout

a. Each floor shall be re-tested 24 hours prior to move in. The test shall ensure all corrective work is complete and all systems are 100% operational.

6. Additional testing, debugging and fine tuning

a. Provide an additional 100 overtime hours of appropriate highest labor cost category to be used at the owner's discretion to test, debug and fine tune the system after occupancy.

C. **Owner System Performance Verification (OSPV)**

1. The systems and equipment shall be fully functional and operational prior to the OSPV process, or the contract(s) will be back-charged accordingly.

2. OSPV is the process in which the contractor fully demonstrates system operation, system performance, proper operation of the sequence of operations, and system equipment to the Owner’s operating staff in the presence of an OSPV agent.

3. After the contractor’s obligations are completed, including system testing, equipment testing, calibration, system demonstration, sequence of operation start-up, training, providing of maintenance and operation manuals, and corrective action for all punchlist items, the OSPV process begins. The BMS contractor shall include in their bid 80 hours (two technicians @ 40 Hours for the OSPV process.

4. Complementary to the BMS contractor's responsibility to commission the building systems, an OSPV agent will be retained by the Owner. This OSPV agent will provide independent equipment-systems installation inspection and performance verification. The independent verification will be requested prior to final equipment and systems acceptance by the Owner. It should be emphasized that independent systems verification prior to the OSPV process does not negate the BMS contractor's obligations to full commission the control system.

5. The OSPV agent will verify system installation, operation, performance, and sequences of operation after the BMS contractor provides written notice that the building system is completed, tested, and fully operational. Upon this notification, the OSPV agent will perform the initial verification. The OSPV agent will provide one (1) additional installation and performance verification, upon notification by the BMS contractor that deficiencies identified have been corrected. Any subsequent installation and performance verification will be at the BMS contractor's expense.

6. All building systems shall be verified under actual and simulated full load conditions.

7. The Owner, Architect, Engineer, and OSPV agent will have input to and be part of the approval process for systems performance verification.

8. The Owner's staff shall be informed of all system start-up, shutdown, and verification procedures that involve any utility usage or interruption.

9. The BMS contractor's technicians provided for the OSPV process shall be thoroughly familiar with the OSPV process (start-up, sequence of operation, shutdown, etc.) and the system or equipment required for the OSPV work. The personnel must also be thoroughly familiar with the project specifications and drawings. Convenient technician substitutes for the OSPV process are unacceptable.

10. Under OSPV, the following shall be verified:

    a. Point to point verification of all BMS points.

    b. The sequence of operation for all systems and equipment.

    c. Calibration of all inputs and outputs.

    d. Operation of the compressed air plant.

    e. System programming.

    f. Standard operation procedures (SOP).

11. The OSPV process includes but is not limited to the above items.

3.6 DEMONSTRATION

A. Maintenance Data and Operating Instructions

1. Description - Maintenance and operating manuals in accordance with Section 01010, General Requirements.

    a. Prepare data in the form of an instructional manual.

2. Manual for Equipment and Systems

    a. Each item of equipment and each system: Include description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include performance curves, with engineering data and test, and complete nomenclature and model number of replaceable parts.

    b. Panelboard Circuit Directories: provide electrical service characteristics, controls, and communications.

    c. Include wiring diagrams as installed.

    d. Operating Procedures: Includes start-up, break-in and routine normal operating instructions and sequences. Include regulation, control stopping, shutdown and emergency instructions. Include summer, winter, and any other special operating instructions.

    e. Maintenance Requirements: Include routine procedures and guide for preventative maintenance, trouble shooting; disassembly repair, re-assembly instructions including alignment, adjusting, balancing, and checking instructions.

    f. Provide servicing and lubrication schedule for dampers and actuators. Provide a list of lubricants required.

    g. Include manufacturers printed operation and maintenance instructions.

    h. Include sequence of operation by controls manufacturer.

    i. Provide original manufacturer's parts list, illustrations, assembly drawings, and diagrams.

    j. Provide control diagrams by controls manufacturer as installed.

    k. Provide contractor's coordination drawings with control piping diagrams as installed.

    l. Provide list of original manufacturer's spare parts. Provide a recommendation of quantities to be maintained in storage.

    m. Provide additional requirements as specified in individual product specification sections.

3. Instruction of Facility Personnel

a. Before final inspection, instruct Owner's designated personnel in operation, adjustment and maintenance of products, equipment, and systems, at agreed upon times.

b. For equipment requiring seasonal operation, perform instruction for other seasons within six months.

c. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.

d. Prepare and insert additional data in Operation and Maintenance manual when need for such data becomes apparent during instruction.

4. After all final tests and adjustments have been completed, fully instruct the proper Owner's Representative in all details of operation for equipment installed. Supply qualified personnel to operate equipment for sufficient length of time to assure that Owner's Representative is properly qualified to take over operation and maintenance procedures. Supply qualified personnel to operate equipment for sufficient length of time as required to meet all governing authorities in operation and performance tests.

5. Instruct Owner on the maintenance instructions for draining and protecting chilled water coils in the winter.

B. Display of Maintenance Instructions

1. One set of operating and maintenance instructions shall be neatly framed behind glass and hung adjacent to the equipment concerned.

C. Training

1. The Contractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays.

2. Provide eighty (80) hours of training for Owner's operating and maintenance personnel. 40 hours shall be off site classroom training and 40 hours shall be on-site training. Videotape all sessions and edit each session to 1-hour tapes. Turn over two copies each unedited and edited tape to the Owner. Training shall include:

a. Explanation of drawings, operator's and maintenance manuals.

b. Walk-through of the job to locate all control components.

c. Operator workstation and peripherals.

d. DDC Controller and ASC operation/function.

e. Operator control functions including graphic generation, if design includes color graphics, and field panel programming.

f. Operation of portable operator's terminal, if an operator terminal is provided to the owner as per this specification.

g. Explanation of adjustment, calibration and replacement procedures.

3. Provide 8 hours of additional training quarterly during warranty period.

4. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, additional training must be available from the Contractor. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training. Provide costs associated with performing training at an off-site classroom facility and detail what is included in the manufacturer's standard pricing such as transportation, meals, etc.

3.7 ON-SITE ASSISTANCE

A. Occupancy Adjustments: Within one year of date of Substantial Completion, provide up to three Project site visits, when requested by the Owner, to adjust and calibrate components and to assist Owner's personnel in making program changes and in adjusting sensors and controls to suit actual conditions.

END OF SECTION 15950

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15951 - SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

B. All set points referenced in this section are subject to change and shall be adjustable from the BMS Operator Workstation and from a Portable Operators Terminal.

C. Related Sections include the following:

1. Division 15 Section "HVAC Instrumentation and Controls" for control equipment and devices and submittal requirements.

1.3 DEFINITIONS

A. AI - Analog Input

B. ANSI - American National Standards Institute

C. AO - Analog Output

D. ASCII - American Standard Code for Information Interchange

E. AWG - American Wire Gauge

F. BMS - Building Management System

G. CPU - Central Processing Unit

H. CRT - Cathode Ray Tube

I. DAC - Digital to Analog Converter

J. DDC - Direct Digital Control

K. DI - Digital Input

L.	DO	-	Digital Output
M.	EEPROM	-	Electronically Erasable Programmable Read Only Memory
N.	EMI	-	Electromagnetic Interference
O.	FAS	-	Fire Alarm Detection and Annunciation System
P.	HOA	-	Hand-Off-Auto
Q.	IEEE	-	Institute of Electrical and Electronics Engineers
R.	I/O	-	Input/Output
S.	LAN	-	Local Area Network
T.	LCD	-	Liquid Crystal Display
U.	LED	-	Light Emitting Diode
V.	MCC	-	Motor Control Center
W.	NC	-	Normally Closed
X.	NO	-	Normally Open
Y.	OWS	-	Operator Workstation
Z.	OAT	-	Outdoor Air Temperature
AA.	PC	-	Personal Computer
BB.	RAM	-	Random Access Memory
CC.	RFI	-	Radio Frequency Interference
DD.	RH	-	Relative Humidity
EE.	ROM	-	Read Only Memory
FF.	RTD	-	Resistance Temperature Detector
GG.	TCP/IP	-	Transmission Control Protocol/Internet Protocol
HH.	UPS	-	Uninterruptible Power Supply
II.	VAC	-	Volts, Alternating Current
JJ.	VAV	-	Variable Air Volume
KK.	VDC	-	Volts, Direct Current
LL.	WAN	-	Wide Area Network.

1.4 PRIMARY HEATING SYSTEM CONTROL SEQUENCES

A. HOT WATER BOILERS

1. GENERAL:

   (a) Service: Main building hot water heating system.

   (b) Hot Water Pump sequence details under Pump Control Sequences.

   (c) Each boiler shall be come with a factory furnished and installed controller for local control of each boiler.

   (d) The BMS contractor shall wire any field control devices furnished with the boiler and installed by the mechanical contractor that could not be factory installed.

   (e) Provide individual controls for each boiler.

   (f) Totalize runtime of the boilers and alternate lead boiler every 168 hours of operation (adj.).

2. SYSTEM OFF:

   (a) Hot Water Pumps: Off.

   (b) Boiler: Disabled.

   (c) Hot Water Valve: Flow through boiler.

3. SYSTEM START:

   (a) The primary hot water system shall be indexed on whenever the outside temperature drops below 50°F (adj) or through a manual command from the BMS.

   (b) Combustion air system shall be enabled.

   (c) Hot Water Pumps: Boiler circulating pump for active boiler shall start. Lead system pump shall start.

   (d) Boiler: Once water flow has proven and the combustion air system has proven the boiler shall be enabled to run under the control of the boiler burner controller.

   (e) Hot Water Valve: Flow through boiler.

4. SYSTEM RUN:

   (a) Hot Water Pumps: Boiler circulating pump on. Lead system pump on. Provide lead/lag and staging control of the pumps.

(b) Boiler: Once enabled the boiler shall operate and control the discharge temperature of the boiler at 180°F (adj) through it's self contained packaged controls.

(c) Hot Water Valve: Shall modulate between full bypass and full flow through the boiler to maintain the desired hot water system supply temperature. The hot water supply temperature set point shall be reset by outside air temperature while maintaining boiler flue condensing as follows:

(1)

OAT	Set Point
50°F	110°F
30°F	150°F
0°F	180°F

5. SYSTEM OFF:

(a) Hot Water Pumps: Off

(b) Boiler: Disabled.

(c) Hot Water Valve: Flow through boiler. When the system is indexed off the hot water pumps shall stop.

6. SAFETIES AND ALARMS:

(a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Boilers shall not be enabled to operate until water flow is proven through water flow switches in hot water supply pipe for each boiler.

(c) Boilers shall not be enabled to run until combustion air dampers and/or fans are proven to be operating.

(d) Annunciate supply water temperature alarms to the BMS if the high or low analog limits are exceeded.

(e) Annunciate common alarm to the BMS from the boiler control panel.

7. FAILURE MODES:

(a) Hot water valve shall fail to full flow through the boilers.

(b) Pump Lead/Lag: An automatic lead/lag program shall start the standby pump in the event of a primary system pump failure.

(c) Pump Failure Alarm: At any time that a pump command does not equal a pump status, except immediately after startup, a pump failure alarm shall be generated on the BMS.

(d) Sensor Failure: Upon the failure of an analog sensor, the system shall be indexed to its "System Off" condition and an alarm shall be annunciated to the BMS.

(e) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

B. PERIMETER RADIATION

1. GENERAL:

(a) Service: General heating (see plans)

2. SYSTEM OFF:

(a) Hot Water Valves: Closed.

3. SYSTEM RUN:

(a) Hot Water Valves: When the outside air temperature drops below 45° F the isolation valves for the perimeter radiation shall open fully and the hot water pumps and heat exchanger must be enabled if not already running.

4. SYSTEM STOP:

(a) Hot Water Valves: When the outside air temperature rises above 47° F the isolation valves shall close fully.

5. FAILURE MODES:

(a) Hot water valve shall fail open.

C. AIR COOLED PACKAGED WATER CHILLERS

1. GENERAL:

(a) Service: Main building chilled water cooling system.

(b) The controls provided by the manufacturer of the chiller shall operate to maintain its programmed chilled water setpoint. The setpoint shall be adjustable from the BMS system through a 4-20 milliamp analog output signal. Start/stop and status shall also be hardwired points to the BMS system primary control panel.

(c) Monitoring shall be via a two-wire BMS network interface to the chiller manufacturer's microprocessor controller (Approximately 50 points per chiller). Use RS-485 or RS-232 communication port for system integration. Chiller manufacturer to provide chiller communication equipment.

(d) The BMS contractor shall furnish, install, and wire all devices necessary for a complete operational chilled water system including but not limited to miscellaneous interlock and control wiring for chillers, refrigerant compressors, pumps, flow switches, etc. The BMS contractor shall mount and wire all components furnished by the chiller manufacturer which are not factory installed. Coordinate requirements with the chiller manufacturer.

(e) All isolation valves shall have individual open and close limit switches to provide positive valve position indication to the BMS.

2. SYSTEM OFF:

(a) Chillers: All Off.

(b) Chilled Water Isolation Valves: Closed

3. SYSTEM START:

(a) Chiller shall start automatically through an outside air temperature interlock or manual command from the BMS.

(b) Upon a need for chilled water, the chiller shall be enabled through the BMS after the lead chilled water pump is started and the necessary valves have been properly positioned. Refer to pump control sequences for further detail.

4. SYSTEM RUN:

(a) The controls provided by the manufacturer of the chiller shall operate to maintain its programmed chilled water supply or return setpoint.

(b) Once started, the chiller shall stay on for a minimum time, determined by the chiller manufacturer.

(c) Provide multiple chiller scheduling to stage chillers ON in order of lowest run time. Chillers shall be staged OFF in order of highest run time.

(d) Additional chillers shall be staged ON in order to meet cooling demand. An additional chiller will be needed if the current chilled water setpoint temperature is unable to be maintained for one (1) minute or more (time is user selectable). Once started, the chillers shall stay on for a minimum time, determined by the chiller manufacturer. The highest run time, on-line chiller shall be staged OFF whenever there is enough cooling capacity of the remaining on-line chillers to carry the cooling load without having to turn that chiller back ON. Provide lead/lag chiller cycling.

(e) Chilled Water Setpoint Reset: The Set point of the chilled water temperature shall be reset to the highest allowable level while maintaining space cooling requirements. Provide chilled water temperature optimization to reduce energy requirements by allowing the chilled water setpoint to increase upward under lower load conditions. Chilled water resetting shall be based on actual load, historical trends and predicted load.

5. SYSTEM STOP:

(a) When the system is indexed off the chiller shall shut down.

6. SAFETIES AND ALARMS:

(a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) The BMS shall monitor chilled water supply and return temperatures and generate an alarm at the BMS workstation if high or low alarm limits are exceeded.

(c) The BMS shall monitor the chilled water vent line level and annunciate an alarm if the level drops below a predetermined level.

(d) The BMS shall monitor all chiller control panel alarms.

7. FAILURE MODES:

(a) Chiller Failure: Upon failure of the lead chiller to start or continue operating an alarm shall be annunciated to the BMS.

(b) Sensor Failure: Upon the failure of an analog sensor, the chiller system shall remain in the last position and an alarm shall be annunciated to the BMS.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.5 PUMP CONTROL SEQUENCES

A. HOT WATER PUMPS WITH VARIABLE SPEED DRIVE CONTROL

1. GENERAL:

(a) Service: Main building hot water heating system.

(b) Control electronically with dedicated control panel.

(c) The differential pressure sensor and bypass valve shall be wired back to the same controller that serves the pumps.

2. SYSTEM OFF:

(a) Hot Water Pumps: Off and VFD set to 0%.

(b) Differential Pressure Bypass Valve: Closed.

3. SYSTEM START:

(a) The pump shall be started and stopped via the BMS system based upon an outside air temperature interlock and/or system requirements. The pump variable frequency drive control algorithm shall be enabled whenever the associated pump(s) are enabled.

(b) Hot Water Pump: Start at 0% once isolation valve has been proven open and slowly ramp up to speed as required by the differential pressure sensor.

(c) Differential Pressure Bypass Valve: Closed.

4. SYSTEM RUN:

(a) Provide individual control loops and control outputs for each variable frequency drive. Pressure sensors shall be located just prior to the last load on the each circuit and be wired to the same Control Panel that controls the pump VFD and bypass valve. The differential pressure setpoint shall be individually controlled.

(b) Hot Water Pump: The variable frequency drive shall modulate as necessary to maintain the loop differential pressure setpoint. Before the pump VFD is modulated above the minimum level, the differential pressure bypass valve shall be fully closed.

(c) Differential Pressure Bypass Valve: Modulate open as required to maintain minimum flow requirements when the VFD's are running at minimum speed setting.

5. SYSTEM STOP:

(a) When the system is indexed off the hot water pumps shall stop.

(b) The VFD shall be set to 0%.

(c) All valves shall be indexed to their "System Off" conditions.

6. SAFETIES AND ALARMS:

(a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Annunciate differential pressure alarms to the BMS if the high or low analog limits are exceeded.

(c) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

7. FAILURE MODES:

(a) Pump Lead/Lag: An automatic lead/lag program shall start the standby pump in the event of a primary pump failure.

(b) Pump Failure Alarm: At any time that a pump command does not equal a pump status, except immediately after startup, a pump failure alarm shall be generated on the BMS.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

B. HOT WATER PUMPS WITH CONSTANT SPEED CONTROL

1. GENERAL:

(a) Service: Boiler circulating pumps.

(b) Control electronically with dedicated control panel, integrated into boiler controls.

(c) The differential pressure sensor and bypass valve shall be wired back to the same controller that serves the pumps.

2. SYSTEM OFF:

(a) Hot Water Pumps: Off.

(b) Hot Water Boiler Isolation Valve: Closed.

3. SYSTEM START:

(a) The pump shall be started and stopped in conjunction with the associated boiler via the BMS system based upon an outside air temperature interlock and/or system requirements.

(b) Hot Water Pump: Start the pump once the associated hot water boiler has been enabled.

4. SYSTEM RUN:

(a) Hot Water Pump: The pump shall run contiguously while the boiler is operating.

5. SYSTEM STOP:

(a) When the associated boiler is indexed off the hot water pumps shall stop and isolation valve shall close.

6. SAFETIES AND ALARMS:

(a) Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Annunciate differential pressure alarms to the BMS if the high or low analog limits are exceeded.

7. FAILURE MODES:

(a) Pump Failure Alarm: At any time that a pump command does not equal a pump status, except immediately after startup, a pump failure alarm shall be generated on the BMS. Upon pump failure, associated boiler shall be disabled. Standby boiler/pump shall start.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.6 AIR HANDLING UNIT CONTROL SEQUENCES

A. MIXED AIR VARIABLE VOLUME AIR HANDLING UNIT

1. GENERAL:

(a) Service: Core VAV air-handling unit.

(b) Control electronically with dedicated control panel.

(c) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

2. SYSTEM OFF:

(a) Supply and Return Fans: Off.

(b) Supply and Return Fan Speed Drives: Set to 0%.

(c) Minimum Outside Air Damper: Closed.

(d) Economizer Dampers: Closed.

(e) Cooling Coil Valve: Closed.

(f) Preheat Coil Valve: Shall modulate to maintain the mixed air plenum temperature at 45° F.

3. SYSTEM START:

(a) The air-handling unit shall be started based upon a start time optimization program, time of day schedule, or manual command from the BMS.

(b) When the air-handling unit is indexed to operate, all return air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper status prior to fan start.

(c) All associated VAV boxes shall be enabled and all fan-powered VAV boxes shall be started prior to the supply fan starting.

(d) The return fan shall start first. Following a 5-second delay, the supply fan shall start.

4. SYSTEM RUN:

(a) Unoccupied Heating Mode:

(1) Supply and Return Fans: Supply and return fans shall run if the space temperature falls below 60° F and continue to run until the space temperature exceeds 64° F. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(4) Cooling Coil Valve: Closed.

(5) Preheat Coil Valve: Modulate to maintain a discharge air temperature at 80° F when the supply and return fans are on.

(6) Static Pressure Control.

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(b) Unoccupied Cooling Mode:

(1) Supply and Return Fans: Cycle supply and return fans to maintain space temperature at the unoccupied cooling setpoint. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers (Dry-bulb): Economizer dampers shall be enabled to provide free cooling when the outside air temperature is below 55° F.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the

outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Open when the supply and return fans are on and when economizer is not available.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control.

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(c) Warm-up Mode:

(1) Shall be invoked when the return air temperature is below 60° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(5) Cooling Coil Valve: Closed.

(6) Preheat Coil Valve: Shall modulate to maintain the mixed air temperature at 55° F when the supply and return fans are on.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(d) Cool-down Mode:

(1) Shall be invoked when the return air temperature is above 80° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Modulate in sequence with the economizer dampers to maintain the discharge air temperature at 55° F at start-up and reset linearly and inversely from 55° F to 65° F as the return air temperature decreases from 80° F to 70° F.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(e) Occupied Mode:

(1) Supply and Return Fans: Supply and return fans shall run continuously.

(2) Minimum Outside Air Dampers: The minimum outside air damper shall modulate open to maintain the minimum outside air setpoint as measured by the outside air volume sensor.

(3) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Cooling Coil Valve: Modulate in sequence with the economizer dampers and heating coil valve to maintain the discharge air temperature at setpoint as reset by space temperature. The discharge setpoint shall be reset from 55° F to 65° F linearly as the average of the space temperature sensors decreases from 75° F to 65° F.

(5) Preheat Coil Valve: Shall modulate to maintain the discharge air temperature of 55° F when the supply and return fans are on.

(6) De-humidification Control:

(i) Fully open Cooling coil valve and modulate the re-heat valves to deliver the proper dry bulb temperature discharge air at a reduced wet bulb temperature to satisfy the de-humidification setpoint (adj.).

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be controlled to maintain the supply static pressure setpoint, as sensed at a point 2/3 downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(8) Provide, install, and wire one return air CO_2 sensor per AHU and monitor from BMS. Whenever CO_2 level exceeds an adjustable setpoint, an alarm shall sound at the BMS and OA damper shall modulate open until alarm is cleared. This automatic program shall be enabled and disabled by the operator through a single command.

5. SYSTEM STOP:

(a) When the air-handling unit is indexed to shut down, the supply and return fans shall stop.

(b) The supply and return speed drives shall be set to 0%.

(c) Dampers, control valves and electric heat shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Outdoor Airflow: If outdoor airflow drops below 5% (adj) of minimum setpoint, as monitored by OA flow sensor, an alarm shall be generated at the BMS.

(c) Low Limit: Manual reset low limit thermostat, mounted upstream of the cooling coil and downstream of the heating coil, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the coil discharge air temperature fall below 38°F.

(d) High Temperature: Manual reset high limit thermostats, mounted at the discharge and return of the unit, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the discharge air or return air temperature exceed 135°F.

(e) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(f) High Static: High discharge pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(g) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(h) Filter Condition: Monitor differential pressures across filter and annunciate alarm when differential pressure set point is exceeded.

(i) Emergency Shutdown:

(1) Room smoke detector(s) shall stop the supply and return fans and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The supply and return fans shall be interlocked to shut down upon a command from the building fire alarm system. Dampers and control valves shall be indexed to their “System Off” conditions.

(j) Annunciate off alarms whenever supply or return fan status does not equal start command.

7. FAILURE MODES:

(a) Fan Failure: If the supply or return fan fails to operate, both fans shall shut down and alarm shall be annunciated. Dampers and control valves shall be indexed to their “System Off” conditions.

(b) Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled. Fans and dampers shall operate normally but electric heat shall be disabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(d) Dampers: Economizer dampers shall be provided with spring return actuators to fail to their “System Off” positions.

(e) Valves:

(1) Heating valves shall be provided with spring return actuators to fail open to the coil.

(2) Cooling valves shall be provided with spring return actuator to fail closed to the coil.

(3) Humidity valves shall be provided with spring return actuators to fail closed to the humidifier.

B. MIXED AIR VARIABLE VOLUME AIR HANDLING UNIT

1. GENERAL:

(a) Service: Airside and Landside air floor air-handling units.

(b) Control electronically with dedicated control panel.

(c) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

2. SYSTEM OFF:

(a) Supply and Return Fans: Off.

(b) Supply and Return Fan Speed Drives: Set to 0%.

(c) Minimum Outside Air Damper: Closed.

(d) Economizer Dampers: Closed.

(e) Cooling Coil Valve: Closed.

(f) Preheat Coil Valve: Shall modulate to maintain the mixed air plenum temperature at 45° F.

3. SYSTEM START:

(a) The air-handling unit shall be started based upon a start time optimization program, time of day schedule, or manual command from the BMS.

(b) When the air-handling unit is indexed to operate, all return air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper status prior to fan start.

(c) All associated VAV boxes shall be enabled and all fan-powered VAV boxes shall be started prior to the supply fan starting.

(d) The return fan shall start first. Following a 5-second delay, the supply fan shall start.

4. SYSTEM RUN:

(a) Unoccupied Heating Mode:

(1) Supply and Return Fans: Supply and return fans shall run if the space temperature falls below 60° F and continue to run until the space temperature exceeds 64° F. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(4) Cooling Coil Valve: Closed.

(5) Preheat Coil Valve: Modulate to maintain a discharge air temperature at 80° F when the supply and return fans are on.

(6) Static Pressure Control.

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(b) Unoccupied Cooling Mode:

(1) Supply and Return Fans: Cycle supply and return fans to maintain space temperature at the unoccupied cooling setpoint. The unit shall run a minimum of ½ hour after start up.

(2) Minimum Outside Air Dampers: Closed.

(3) Economizer Dampers (Dry-bulb): Economizer dampers shall be enabled to provide free cooling when the outside air temperature is below 55° F.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Open when the supply and return fans are on and when economizer is not available.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control.

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(c) Warm-up Mode:

(1) Shall be invoked when the return air temperature is below 60° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers: Outside air and exhaust dampers are closed and return air damper is open.

(5) Cooling Coil Valve: Closed.

(6) Preheat Coil Valve: Shall modulate to maintain the mixed air temperature at 55° F when the supply and return fans are on.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(d) Cool-down Mode:

(1) Shall be invoked when the return air temperature is above 80° F upon start-up.

(2) Supply and Return Fans: Supply and return fans shall start and run continuously.

(3) Minimum Outside Air Dampers: Closed.

(4) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(5) Cooling Coil Valve: Modulate in sequence with the economizer dampers to maintain the discharge air temperature at 55° F at start-up and reset linearly and inversely from 55° F to 65° F as the return air temperature decreases from 80° F to 70° F.

(6) Preheat Coil Valve: Closed.

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(e) Occupied Mode:

(1) Supply and Return Fans: Supply and return fans shall run continuously.

(2) Minimum Outside Air Dampers: The minimum outside air damper shall modulate open to maintain the minimum outside air setpoint as measured by the outside air volume sensor.

(3) Economizer Dampers (Wet-bulb): Economizer mode shall be available whenever the outside air enthalpy is less than the air handling unit return air enthalpy.

(i) Economizer Available: If economizer is available and there is a rise in temperature above temperature setpoint, the outside air damper(s) and/or exhaust air damper(s) shall be modulated open from minimum position to 100% open as necessary to maintain temperature setpoint and airflow set points. The return air damper(s) shall modulate closed as the outside air and exhaust air damper(s) modulate open. If the outside air damper is 100% open and there is a further rise in temperature above temperature setpoint, the outside air damper shall remain 100% open and the cooling valve shall be

modulated open as necessary to maintain temperature setpoint. Economizer dampers shall modulate in sequence with the cooling coil valve subject to a mixed air low limit of 50° F.

(ii) Economizer Not Available: Outside air damper shall close, the return air damper shall open and exhaust dampers shall close.

(4) Cooling Coil Valve: Modulate in sequence with the economizer dampers and heating coil valve to maintain the discharge air temperature at setpoint as reset by space temperature. The discharge setpoint shall be reset from 55° F to 65° F linearly as the average of the space temperature sensors decreases from 75° F to 65° F.

(5) Preheat Coil Valve: Shall modulate to maintain the discharge air temperature of 55° F when the supply and return fans are on.

(6) De-humidification Control:

(i) Fully open Cooling coil valve and modulate the re-heat valves to deliver the proper dry bulb temperature discharge air at a reduced wet bulb temperature to satisfy the de-humidification setpoint (adj.).

(7) Static Pressure Control:

(i) The supply fan variable speed drive shall be monitored to maintain the supply static pressure setpoint, as sensed at a point downstream of the supply fan.

(ii) The return fan variable speed drive shall be controlled to maintain a constant air volume differential, as measured by the supply and return air-flow measuring stations, to maintain positive pressurization of the space. The return air CFM setpoint shall be calculated from the supply CFM minus exhaust losses.

(8) Provide, install, and wire one return air CO_2 sensor per AHU and monitor from BMS. Whenever CO_2 level exceeds an adjustable setpoint, an alarm shall sound at the BMS and OA damper shall modulate open until alarm is cleared. This automatic program shall be enabled and disabled by the operator through a single command.

5. SYSTEM STOP:

(a) When the air-handling unit is indexed to shut down, the supply and return fans shall stop.

(b) The supply and return speed drives shall be set to 0%.

(c) Dampers, control valves and electric heat shall be indexed to their "System Off" conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Outdoor Airflow: If outdoor airflow drops below 5% (adj) of minimum setpoint, as monitored by OA flow sensor, an alarm shall be generated at the BMS.

(c) Low Limit: Manual reset low limit thermostat, mounted upstream of the cooling coil and downstream of the heating coil, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the coil discharge air temperature fall below 38°F.

(d) High Temperature: Manual reset high limit thermostats, mounted at the discharge and return of the unit, shall stop the supply and return fans, close the outdoor air dampers and cooling coil valve and annunciate alarm to the BMS should the discharge air or return air temperature exceed 135°F.

(e) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(f) High Static: High discharge pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(g) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(h) Filter Condition: Monitor differential pressures across filter and annunciate alarm when differential pressure set point is exceeded.

(i) Emergency Shutdown:

(1) Room smoke detector(s) shall stop the supply and return fans and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The supply and return fans shall be interlocked to shut down upon a command from the building fire alarm system.

Dampers and control valves shall be indexed to their "System Off" conditions.

(j) Annunciate off alarms whenever supply or return fan status does not equal start command.

7. FAILURE MODES:

(a) Fan Failure: If the supply or return fan fails to operate, both fans shall shut down and alarm shall be annunciated. Dampers and control valves shall be indexed to their "System Off" conditions.

(b) Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled. Fans and dampers shall operate normally but electric heat shall be disabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(d) Dampers: Economizer dampers shall be provided with spring return actuators to fail to their "System Off" positions.

(e) Valves:

(1) Heating valves shall be provided with spring return actuators to fail open to the coil.

(2) Cooling valves shall be provided with spring return actuator to fail closed to the coil.

(3) Humidity valves shall be provided with spring return actuators to fail closed to the humidifier.

1.7 VENTILATION UNITS CONTROL SEQUENCES

A. OUTDOOR AIR INTAKE FANS WITH EQUIPMENT INTERLOCK CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Outdoor Air Intake Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Outdoor Air Intake Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command. Provide start contact and speed setpoint to each fan variable frequency drive. Drive shall start unloaded and slowly ramp up to speed as required.

(b) Damper: Upon a command to start, all associated outside air dampers, discharge air dampers, smoke dampers, and associated fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Outdoor Air Intake Fan: The fan shall be energized whenever an interlocked air handling unit is running. The fan shall run continuously. The fan variable speed drive shall be controlled to maintain the supply CFM setpoint, as sensed by a supply airflow measuring station. The CFM setpoint shall be calculated by adding the CFM requirements of all running, interlocked air handling units. If there is more than one supply fan, provide an airflow monitoring station for each fan.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Outdoor Air Intake Fan: When the fan is indexed to shut down, the outdoor air intake fan shall stop and the fan speed drive(s) shall be set to 0%.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans

shall remain off until the pressure switch is manually reset.

(d) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(e) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(f) Emergency Shutdown:

(1) Duct smoke detector shall stop the outdoor air intake fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The outdoor air intake fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

B. GENERAL EXHAUST FAN GREATER THAN 2000 CFM

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual

command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Emergency Shutdown:

(1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to

operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

C. GENERAL EXHAUST FAN LESS THAN 2000 CFM

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Emergency Shutdown:

(1) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

D. GENERAL EXHAUST FAN LESS THAN 2000 CFM NON-BMS LOCAL CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, intake air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

5. SYSTEM STOP:

(a) Exhaust Fan: When the fan is indexed to shut down, the fan shall stop.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: High discharge pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Emergency Shutdown:

(1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

(e) Smoke Purge:

(1) When smoke purge is required, the FAS shall open the exhaust damper and start the designated smoke purge fan.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

E. VARIABLE VOLUME EXHAUST FAN WITH STATIC PRESSURE CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

(c) Fan Speed Drive: Set to 0%.

3. SYSTEM START:

(a) Exhaust Fan: The fan shall be started through the BMS based upon a start time optimization program, time of day schedule, or manual command.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

(c) Fan Speed Drive: Start at 0% and slowly ramp up to speed.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

(c) Fan Speed Drive: Modulate to maintain the riser static pressure setpoint 2/3 down the riser shaft.

5. SYSTEM STOP:

(a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

(b) Damper: Dampers shall be indexed to their “System Off” conditions.

(c) Fan Speed Drive: Speed drives shall be set to 0%.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans

shall remain off until the pressure switch is manually reset.

(d) Variable Frequency Drive: The BMS shall monitor and alarm the variable frequency drive RPM, fault alarm, common alarm, bypass status and KW.

(e) Static Pressure Alarm: If the static pressure setpoint cannot be maintained and the fan speed drive is at 95% or higher, sound an alarm at the BMS.

(f) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(g) Emergency Shutdown:

(1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

F. EXHAUST FAN WITH SPACE TEMPERATURE CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

   (a) Exhaust Fan: The fan shall be started whenever the space temperature rises above the space temperature setpoint of 80°F.

   (b) Damper: When the fan is indexed to operate, all exhaust air dampers, intake air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

   (a) Exhaust Fan: Fan shall run based on the space temperature sensor.

   (b) Damper: Remain full open.

5. SYSTEM STOP:

   (a) Exhaust Fan: When the temperature is at or below setpoint the fan shall stop.
   (b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Temperature Alarms: Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

   (c) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (d) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (e) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

   (f) Emergency Shutdown:

      (1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

      (2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Sensor Failure: Upon the failure of the analog duct static pressure sensor, fan speed drive shall remain at the last position and an alarm shall be annunciated.

(c) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(d) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

G. LOADING DOCK EXHAUST FAN WITH CARBON MONOXIDE CONTROL

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Exhaust Fan: Off.

(b) Damper: Fully closed.

3. SYSTEM START:

(a) Provide two carbon monoxide sensors per exhaust fan. The fan shall be energized whenever the carbon monoxide level, as sensed by either of the carbon monoxide sensors, exceeds the carbon monoxide setpoint. The BMS shall monitor the CO level at each CO sensor and provide manual fan override control.

(b) Damper: When the fan is indexed to operate, all exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Exhaust Fan: Fan shall run continuously.

(b) Damper: Remain full open.

5. SYSTEM STOP:

   (a) Exhaust Fan: When the fan is indexed to shut down, the exhaust fan shall stop.

   (b) Damper: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (c) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

   (d) Emergency Shutdown:

      (1) Duct smoke detector shall stop the exhaust fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

      (2) The exhaust fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

   (a) Fan Failure: If the exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

   (b) Power Failure:

      (1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

      (2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

   (c) Dampers: Exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

H. SWITCH GEAR ROOM VENTILATION

1. GENERAL:

(a) Service: See mechanical equipment schedule.

2. SYSTEM OFF:

(a) Supply Fan: Off.

(b) Exhaust Fan: Off.

(c) Dampers: Closed.

3. SYSTEM START:

(a) The supply and exhaust fan shall be energized via the space thermostat whenever the space temperature rises above the space temperature setpoint of 80F (adj). Fan shall be de-energized when space temperature is at or below setpoint.

(b) Damper: When the fan is indexed to operate, all outdoor air dampers, exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

(a) Supply Fan: Fan shall run continuously.

(b) Exhaust Fan: Fan shall run continuously.

(c) Dampers: Remain full open.

5. SYSTEM STOP:

(a) Fans shall be de-energized when space temperature is at or below setpoint.

(b) Dampers: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) Temperature Alarms: Annunciate space temperature alarms to the BMS if the space temperature exceeds the space temperature alarm limit of 95F (adj.)

(c) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(e) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(f) Emergency Shutdown:

(1) Room smoke detector shall stop the fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the supply or exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Outdoor air and exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

I. NETWORK ROOMS

1. GENERAL:

(a) Service: See mechanical equipment schedule.

(b) The BMS shall monitor flow switches for each transfer vault or network room.

(c) Provide all thermostats, wiring, alarm panels, dampers, etc. as required by Con Edison and division 16.

2. SYSTEM OFF:

   (a) Supply Fan: Off.

   (b) Exhaust Fan: Off.

   (c) Dampers: Closed.

3. SYSTEM START:

   (a) Three space thermostats shall be installed per transformer vault or network room. The supply and exhaust fan shall be energized via any one of three space thermostats whenever the space temperature rises above the space temperature setpoint of 80F (adj).

   (b) Damper: When the fan is indexed to operate, all outdoor air dampers, exhaust air dampers, smoke dampers and fire/smoke dampers shall open. Where required, hard-wired damper end switches shall prove damper open status prior to fan start.

4. SYSTEM RUN:

   (a) Supply Fan: Fan shall run continuously.

   (b) Exhaust Fan: Fan shall run continuously.

   (c) Dampers: Remain open.

5. SYSTEM STOP:

   (a) Exhaust Fan: Fan shall be de-energized when space temperature is at or below setpoint.

   (b) Dampers: Dampers shall be indexed to their “System Off” conditions.

6. SAFETIES AND ALARMS:

   (a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

   (b) Temperature Alarms: Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

   (c) Low Suction: A low suction pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(d) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their “System Off” conditions. The fans shall remain off until the pressure switch is manually reset.

(e) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(f) Emergency Shutdown:

(1) Room smoke detector shall stop the fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detector shall be wired into the building fire alarm system.

(2) The fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers shall be indexed to their “System Off” conditions.

7. FAILURE MODES:

(a) Fan Failure: If the supply or exhaust fan fails to operate an alarm shall be annunciated at the BMS. Dampers shall be indexed to their “System Off” conditions.

(b) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

(c) Dampers: Outdoor air and exhaust dampers shall be provided with spring return actuators to fail to their “System Off” positions.

1.8 TERMINAL UNIT CONTROL SEQUENCES

A. VARIABLE AIR VOLUME (VAV) BOX WITH NO REHEAT

1. GENERAL:

(a) Service: See mechanical equipment schedule.

(b) Provide one DDC controller and at least one thermostat for each VAV box.

(c) The minimum and maximum CFM settings shall be those scheduled on the drawings.

(d) The VAV box damper shall not open beyond the maximum CFM setting.

(e) Coordinate factory mounting and wiring of controller, actuator, and transformer with the VAV box manufacturer. The BMS contractor shall be responsible for furnishing, installing, and wiring any controls not furnished, installed, or wired by others that are required for an operational system.

2. SYSTEM OFF:

(a) VAV box damper: Closed.

3. SYSTEM START:

(a) VAV box damper: Modulate open to maintain CFM setpoint.

4. SYSTEM RUN:

(a) System run is determined by the status of the air handling system serving the VAV box.

(b) Unoccupied Heating Mode:

(1) VAV box damper: Modulate to maintain the unoccupied space setback temperature at setpoint.

(c) Unoccupied Cooling Mode:

(1) VAV box damper: Modulate to maintain the unoccupied space setup temperature at setpoint.

(d) Warm-up Mode:

(1) VAV box damper: Modulate to maintain the warm-up space temperature at setpoint.

(e) Cool-down Mode:

(1) VAV box damper: Modulate to maintain the cool-down space temperature at setpoint.

(f) Occupied Mode:

(1) VAV box damper: Modulate to maintain the space temperature at setpoint. As the space temperature rises above the space temperature setpoint, the DDC controller shall modulate the VAV box damper from the minimum to the maximum CFM setting as necessary to maintain the space temperature at setpoint.

(g) Occupied Override Mode:

(1) The VAV box controller shall be programmed for occupancy override. By depressing the occupancy override button located on the space temperature sensor or via a BMS system override, the VAV box shall restore to the “Occupied Mode” condition.

5. SYSTEM STOP:

(a) VAV box damper: Shall be indexed to its “System Off” condition.

6. SAFETIES AND ALARMS:

(a) Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

(b) Annunciate CFM alarms to the BMS if the high and low analog limits are exceeded.

7. FAILURE MODES:

(a) Fan Failure: If the fan serving the VAV box fails to operate, the VAV box damper shall be indexed to its “System Off” condition.

(b) Sensor Failure: Upon the failure of an analog sensor, the VAV box damper shall remain in its last position and an alarm shall be annunciated to the BMS.

(c) Power Failure:

(1) Upon a power failure, the VAV box damper shall remain in it’s last position.

B. SERIES FAN POWERED BOX WITH NO REHEAT

1. GENERAL:

(a) Service: See mechanical equipment schedule.

(b) Provide one DDC controller and at least one thermostat for each FPVAV box.

(c) The minimum and maximum CFM settings shall be those scheduled on the drawings. The FPVAV box damper shall not open beyond the maximum CFM setting.

(d) Coordinate factory mounting and wiring of controller, actuator, and transformer with the FPVAV box manufacturer. The BMS contractor shall be responsible for furnishing, installing, and wiring any controls not furnished, installed, or wired by others that are required for an operational system.

2. SYSTEM OFF:

   (a) FPVAV Box Fan: Off.

   (b) FPVAV Box Damper: The re-circulated air damper shall be open as the supply air damper closed.

3. SYSTEM START:

   (a) System start is determined by the start of the air handling system serving the FPVAV box.

   (b) FPVAV Box Fan: Shall start prior to the supply fan serving the area.

   (c) FPVAV Box Damper: The re-circulated air damper shall modulate closed as the supply air damper modulates open.

4. SYSTEM RUN:

   (a) System mode is determined by the status of the air handling system serving the FPVAV box.

   (b) Unoccupied Heating Mode:

      (1) FPVAV Box Fan: On if the space temperature falls below the unoccupied setpoint of 62F and remain on until the space temperature exceeds the unoccupied setpoint or for a period of 15 minutes, whichever is greater.

      (2) FPVAV Box Damper: The re-circulated air damper shall be full open and the supply air damper shall be full closed.

   (c) Unoccupied Cooling Mode:

      (1) FPVAV Box Fan: On.

      (2) FPVAV Box Damper: Modulate to maintain the unoccupied cooling CFM setpoint.

   (d) Warm-up Mode:

      (1) FPVAV Box Fan: On.

      (2) FPVAV Box Damper: Modulate to maintain the warm-up CFM setpoint.

   (e) Cool-down Mode:

      (1) FPVAV Box Fan: On.

      (2) FPVAV Box Damper: Modulate to maintain the cool-down CFM setpoint.

(f) Occupied Mode:

(1) FPVAV Box Fan: On.

(2) FPVAV Box Damper: Modulate to maintain the occupied space temperature setpoint. Upon a rise in space temperature above setpoint, the DDC controller shall modulate the VAV box damper open from the minimum supply CFM setting to the maximum supply CFM setting as necessary to maintain the space temperature at setpoint.

(g) Occupied Override Mode:

(1) The FPVAV box controller shall be programmed for occupancy override. By depressing the occupancy override button located on the space temperature sensor or via a BMS system override, the FPVAV box shall restore to the "Occupied Mode" condition.

5. SYSTEM STOP:

(a) FPVAV Box Fan: Off

(b) FPVAV Box Damper: Shall be indexed to the "System Off" condition.

6. SAFETIES AND ALARMS:

(a) Annunciate space temperature alarms to the BMS if the high or low analog limits are exceeded.

(b) Annunciate CFM alarms to the BMS if the high and low analog limits are exceeded.

(c) Emergency Shutdown:

(1) When the primary air handling unit serving the associated FPVAV receives an input from the fire alarm system, all FPVAV fans shall be de-energized and all FPVAV primary air dampers shall close. Shutdown shall be performed on a floor by floor basis based on inputs from the FAS.

(2) During smoke purge the primary air damper shall be open and the return air damper shall be closed.

7. FAILURE MODES:

(a) Fan Failure: If the fan serving the FPVAV box fails to operate, the FPVAV box damper shall be indexed to it's "System Off" condition.

(b) Sensor Failure: Upon the failure of an analog sensor, the FPVAV box damper shall remain in its last position and an alarm shall be annunciated to the BMS.

(c) Power Failure:

(1) FPVAV Box Damper: Upon a power failure shall remain in its last position.

1.9 MISCELLANEOUS SYSTEM CONTROL SEQUENCES

A. ENERGY METERING

1. Hot And Chilled Water Metering

(a) The hot and chilled water BTU usage shall be monitored, trended and reported.

(b) The actual daily, weekly, monthly, and annual BTU usage shall be monitored and trended and the associated reports generated on a monthly basis. The report shall be Excel spreadsheet based.

(c) Submit report format for approval.

B. WATER TREATMENT SYSTEM

1. The Mechanical contractor shall provide and install the water treatment system. This contractor shall provide all power and control wiring necessary for a completely operational system.

2. The BMS contractor shall furnish and wire the solenoid valve for blow down and the water meter for make-up lines.

3. The BMS shall monitor the common alarm and conductivity level for each system.

C. HOT WATER UNIT HEATER

1. Hot Water Unit Heater Not Monitored by BMS

(a) The BMS contractor shall furnish, install, and wire a space thermostat to control the unit heater. On a fall in space temperature below setpoint, the thermostat shall energize the unit fan. On a rise in space temperature, the fan shall be de-energized.

(b) For a hot water unit heater, a pipe-mounted electric aquastat shall lock out the fan if hot water is not available.

2. Steam, Electric, or Hot Water Unit Heater Monitored by BMS

(a) Alarm

(1) An alarm shall be annunciated on the BMS if the space temperature exceeds the high or low alarm limits.

(b) The BMS contractor shall furnish, install, and wire a space temperature sensor to control the unit heater fan. On a fall in space temperature below the setpoint of 60F (adj), the DDC controller shall energize the unit fan. On a rise in space temperature, the fan shall be de-energized.

(c) If steam or hot water unit heater, a hard-wired, pipe-mounted electric aquastat shall lock out the fan if hot water is not available.

(d) The space temperature sensor and fan status shall be a BMS input. The fan control shall be a BMS output. Fan status shall be monitored via a current sensing relay.

D. HOT WATER CABINET UNIT HEATER

1. Hot Water Cabinet Unit Heater Not Monitored by the BMS

(a) The BMS contractor shall furnish, install, and wire a thermostat and control valve to control the unit heater. On a fall in space temperature below setpoint, the thermostat shall open the valve and energize the unit fan. On a rise in space temperature, the fan shall be de-energized and the valve shall close.

(b) For a hot water cabinet unit heater, a pipe-mounted electric aquastat shall lock out the fan and lock the valve closed if hot water is not available.

2. Hot Water Cabinet Unit Heater Monitored by the BMS

(a) Alarm

(1) An alarm shall be annunciated on the BMS if the space temperature exceeds the high or low alarm limits.

(b) The BMS contractor shall furnish, install, and wire a space temperature sensor to control the hot water valve and fan. On a fall in space temperature below setpoint, the DDC controller shall open the valve and energize the unit fan. On a rise in space temperature, the fan shall be de-energized and the valve shall close.

(c) The space temperature sensor and fan status shall be a BMS input. The fan and heating valve control shall be a BMS output. Fan status shall be monitored via a current sensing relay.

(d) If steam or hot water cabinet unit heater, a hard-wired, pipe-mounted electric aquastat shall lock out the fan if hot water is not available.

E. EQUIPMENT RESTART PROGRAM

1. Subsequent to any building wide equipment shutdown, due to power failure, smoke control, occupancy scheduling, priority lead shedding, etc., the mechanical equipment (with the exclusion of those supplied with emergency power) restarts shall be staggered and phased to minimize peak electrical loads. Time delays shall be adjustable and shall be provided for each controlled motor. The final restart sequence shall be submitted for approval.

2. All units shall be remotely reset and restarted from the BMS after a safety shutdown.

F. EXPANSION TANKS

1. Operation

(a) Install and wire all devices necessary for expansion tank level controls including devices furnished by the expansion tank manufacturer. Furnish, install, and wire any devices not furnished by the expansion tank manufacturer which are necessary for a completely operational system.

(b) Provide high pressure (80 psi) compressed air schrader valve connection with a hand and check valve, within 10 feet of expansion tanks requiring air charging.

G. AIR FILTER (CARBON, HEPA, BOX, BAG TYPES)

1. The BMS system shall monitor the actual differential pressure across each filter. An alarm shall be generated if the differential pressure exceeds design conditions.

H. HEAT TRACE

1. The BMS shall monitor a common alarm contact from each heat trace control panel.

2. The BMS shall override the heat trace system on and sound an alarm if outside air temperature falls below 40°F and the heat trace system has not activated.

I. DOMESTIC HOT WATER HEATERS

1. The BMS contractor shall install and wire all devices supplied by the domestic hot water heater manufacturer. The BMS contractor shall furnish, install, and wire any devices not furnished by the domestic hot water heater manufacturer that are necessary for a completely operational domestic hot water heating system

2. The BMS shall monitor common alarm and supply water temperature. If an abnormal condition exists, an alarm shall sound at the BMS

J. FUEL OIL SYSTEM (ASSOC – EMERGENCY GENERATOR & TRANSFER SWITCHES)

1. Install and wire all fuel oil level-sensing equipment for fuel oil tanks. Install and wire all fuel oil leak-sensing equipment for tanks and containment piping. Fuel oil leak and level panels shall be installed in the fuel oil pump areas.

2. Provide remote tank level (gallons) readout panels for the fuel oil tank **[add location].** Provide all fuel oil pump status lights on each panel. The panel shall operate whether the BMS is operational or not.

3. Furnish and install hardwire interlock between the generator start and generator fuel oil pump start.

4. Provide and install fuel oil tank level sensors in fuel oil storage tank. Monitor level and actual fuel stored (in gallons). Provide all power and control wiring as required.

5. Provide and install fuel oil tank overfill alarm at tank. Provide all power and control wiring as required.

6. Provide and install fuel oil tank overfill alarm light and horn at tank fill connection on loading dock. Strobe light shall be activated whenever tank level exceeds 95% of capacity. Alarm horn shall be activated whenever tank level exceeds 99% of capacity. Provide key operated silence switch and key operated alarm light disable switch at tank fill connection.

7. Provide one DDC controller for each system.

K. EMERGENCY GENERATOR (ASSOC – FUEL OIL SYSTEM AND TRANSFER SWITCHES)

1. Enabled Mode

(a) Whenever the emergency generator is energized, its bypass damper shall open and the fuel oil control system shall be enabled. When the generator is de-energized, the bypass damper shall close and the fuel oil control system shall be disabled.

(b) The BMS contractor shall install a hardwired and/or pneumatic interlock between the associated ventilation damper sections and each generator. Damper operators and fan lines shall be sized to provide a maximum open/close time of 10 seconds. If pneumatics are utilized, dampers shall be piped in _" copper (minimum) to ensure full open dampers within 10 seconds. EP solenoids with _" orifice shall be located at damper. Outside air and spill dampers shall fail open on a loss of power or compressed air.

(c) A space thermostat shall modulate the bypass, spill and outside dampers to maintain its setting of 85 F. As the space temperature rises, the bypass damper shall gradually close and the outside and spill damper shall gradually open. On a decrease in temperature the reverse shall occur.

(d) Whenever the emergency generator is energized, all associated booster fan dampers, smoke dampers and/or fire/smoke dampers shall open. After the dampers are open, the associated emergency generator booster fan shall be energized. If the booster fan is greater than 2000 CFM, the fan shall not be energized until individual endswitches indicate that all associated dampers are open. When the emergency generator is de-energized, the booster fan shall continue to run until the emergency generator space temperature falls below 95F (adj.). When space temperature falls below the space temperature setpoint, the booster fan shall be de-energized and all associated dampers shall close.

(e) Each generator shall have its own individual damper sections.

(f) Provide one DDC controller for each emergency generator.

L. AUTOMATIC TRANSFER SWITCHES (ASSOC – FUEL OIL SYSTEM & EMERGENCY GENERATOR).

1. The BMS shall monitor the following points for each automatic transfer switch. Refer to electrical drawings for quantity and location.

(a) Connected to normal.

(b) Connected to emergency.

(c) Normal source available.

(d) Emergency source available.

(e) Automatic transfer switch in load shed.

M. SYSTEM INTEGRATION

1. General

(a) Furnish, install, and wire a communications interface between the BMS and the system to be integrated. Furnish, install, and wire all components necessary for a fully operational system interface.

(b) Data transfer rate shall be sufficient to maintain data as current to within 15 seconds.

(c) Provide one graphic page per floor for each foreign system.

(d) The integration modules shall be coordinated, installed and started up prior to the start up and check out of the foreign system. All data shall be checked for accuracy on both “sides” of the serial interface during the foreign system commissioning process. Provide all labor as required.

2. Chiller

(a) Furnish, install, and wire a communications interface between the BMS and the chiller control system. The BMS manufacturer shall be responsible for providing all hardware needed for a completely operational interface. This includes any hardware manufactured by the chiller manufacturer which is necessary for a completely operational interface.

(b) Provide two way serial communication hardware and software to interface with chiller control system to monitor and reset all chiller units.

3. Fire Alarm System

4. Lighting Control System

5. Security System

N. PRIORITY LOAD SCHEDULING SYSTEM

O. VARIABLE FREQUENCY DRIVE (VFD)

1. Control each variable speed drive as specified.

2. Monitor RPM, fault alarm, common alarm, bypass status, and KW of each VFD.

3. Provide start contact and speed set point to each VFD.

4. Variable frequency drives shall start unloaded and slowly ramp up to speed as required.

5. The DDC controllers shall calculate flow (air or water) rate based on RPM, equipment operating curves and actual balancing data where no air flow measuring stations or water flow meters are specified.

P. PAGING SOFTWARE

1. Pager interface software utilized to page building operators and maintenance personnel when user specified alarms occur.

Q. ELEVATOR CONTROL AND COMPUTER ROOM AIR CONDITIONING UNIT

1. GENERAL:

(a) Service:

(b) CAC units shall run and operate under unit mounted controls with remote setpoint reset and automatic restart from the BMS.

(c) Each CAC unit shall be furnished with the unit manufacturer's factory mounted and wired microprocessor controller. Each CAC unit mounted controller shall be wired, by the BMS contractor, to centrally located communications interface devices that will be furnished with the CAC units.

(d) The BMS contractor shall provide an interface to connect into the communications interface via open protocol standards (i.e. Modbus or BACnet) for control and monitoring of the CAC units.

2. SAFETIES AND ALARMS:

(a) Reset / Restart: Any safety shutdown shall allow for local manual reset and restart from the BMS system.

(b) High Static: A high discharge pressure switch shall stop the fan when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(c) Low Suction: Low suction pressure switches shall stop the supply and return fans when duct pressure exceeds design and annunciate an alarm. Dampers shall be indexed to their "System Off" conditions. The fans shall remain off until the pressure switch is manually reset.

(d) Filter Condition: Monitor differential pressures across filters and annunciate alarm when differential pressure set points are exceeded.

(e) Water Leak Detection: A water leak detector, installed as per the Water Leak Detection specification section, shall stop the supply fan and annunciate an alarm whenever a water leak is detected. The fan shall remain off until the switch is reset.

(f) Emergency Shutdown:

(1) Duct smoke detector shall stop the fan and annunciate an alarm when products of combustion are detected in the air stream. The duct smoke detectors shall be wired into the building fire alarm system.

(2) The fan shall be interlocked to shut down upon a command from the building fire alarm system. Dampers and control valves shall be indexed to their "System Off" conditions.

3. FAILURE MODES:

(a) Fan Failure: If the fan fails to operate, an alarm shall be annunciated and dampers and control valves shall be indexed to their “System Off” conditions.

(b) Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain at their last position and alarm shall be annunciated.

(c) Wall mounted room sensor shall monitor room temperatures for CAC-23 to CAC-31. Should room temperature exceed set point, an alarm shall be sounded, the unit shall shut down, and the emergency dampers shall close to the unit and open to the floor supply dectwork.

(d) Power Failure:

(1) Upon a power failure, the equipment that is scheduled to operate under emergency power shall be enabled.

(2) Upon restoration of normal power, the equipment that is scheduled to run under normal power shall be enabled in a staggered fashion.

1.10 SPECIAL DESIGN CONSIDERATIONS

A. LABORATORY

1. FUME HOOD CONSTANT VOLUME MONITOR

(a) The Constant Volume Monitor shall be applicable to the following fume hood exhaust configurations:

(1) Manifolded exhaust system.

(2) Individual exhaust system at each hood.

(b) The fume hood control system shall be applicable to the following fume hood sash configurations:

(1) Single vertical sash (e.g., bench hood).

(2) Two side-by-side vertical sashes (e.g., bench hood).

(3) Two overlapping vertical sashes (e.g., distillation or walk-in hood).

(4) Four sashes as two sets, side-by-side, of two overlapping sashes (e.g., walk-in hood).

(5) Two, three or four horizontal sashes sliding in one or two

tracks (e.g., bench, walk-in).

(6) Combination sash consisting of one vertical sash segment containing two, three or four horizontal sashes sliding in one or two tracks (e.g., bench).

(c) Provide for each fume hood a separate fume hood monitor with the following capabilities:

(1) The fume hood monitor shall be stand-alone and microprocessor based. The monitor shall have integral sensors (e.g., temperature compensation and airflow).

(2) Fume hood monitors shall have the capability of being networked to the building control system without the use of gateways, and all data must be available to designated operator terminals and PC workstations. The fume hood monitor shall be capable of operating in occupied and unoccupied modes with user definable setpoints for each mode. The switching of occupied and unoccupied modes shall be accomplished via the network or a local switch.

(3) Fume hood monitor shall include user definable push buttons.

(4) All data in the fume hood monitor shall be maintained in non-volatile EEPROM type of memory. Momentary or extended losses of power shall not change or affect any of the monitor's setpoints, calibration settings, or emergency mode programming.

(5) The fume hood monitor shall interface to the BMS.

(6) The fume hood monitor shall measure and indicate average face velocity at all times. The fume hood monitor must be field-calibratable with password-protected software to prevent tampering. Alarm setpoint shall be capable of being changed by lab safety personnel using the Portable Operator's Terminal (POT) connected to the fume hood monitor. The fume hood monitor shall have selectable digital indication of average face velocity (FPM, MPS or no indication).

(7) Each fume hood monitor shall have spare input and output points for connection to external devices. External devices are defined as motion sensors, external horns, room lights, external hardwired alarm panels, photocells, etc.

(8) The fume hood monitor shall comply with the following agency listings:

(i) UP 916, PAZX (Energy Management)

(ii) UP 864, UUKL (Smoke Control)

(iii) UP 864, UDTZ (Signal Management)

(iv) UP 916, QUAY (Process Management)

(9) To increase safety for individual fume hood operators: If the sash is raised above the safe operating height for a user-programmable time period, the monitor will have the capability of sounding an audible alarm for two seconds every 58 seconds.

(10) Calibration of the air velocity sensor of the fume hood monitor shall require a minimum of three (3) calibration points to ensure accurate measurement at all possible sash positions/heights and over the expected range of airflow. Monitors that use only one (1) or two (2) calibration points or monitors that cannot be field programmable are unacceptable

(11) Indicator lights green and red (normal, alarm). The GREEN light shall indicate normal condition. RED will indicate a programmable alarm condition. In alarm (RED), an audible horn will initiate. The horn shall be turned off as the RED light is turned off. The indicator lights/horn sequence is intended to be the hood user's primary indication of safe operation. The face velocity high/low alarm limits, and time delays shall be capable of being set by safety personnel based on the type of chemicals being used in and the performance characteristics of each hood.

(12) Alphanumeric display of the type of alarm/emergency condition, indicating "LOW face velocity" or "HIGH face velocity" and "EMERGENCY" when the emergency button has been pushed. A diagnostic message shall be provided to notify hood operator of flow sensor failure.

(13) An "emergency" button. When pressed, the controller shall respond immediately by turning on the RED alarm light and horn.

(14) Horn silence button. When pressed while the horn is sounding, it shall turn the horn off.

(15) A terminal jack for connection to the portable operator's terminal to monitor/edit all points internal to the fume hood monitor. As a minimum, the following points must be available to be programmed and adjustable from the terminal jack: Face velocity, low alarm, high alarm, emergency alarm, occupied/unoccupied, 2 auxiliary input buttons, field calibration, display averaging, engineering units, general failure, high alarm limit, low alarm limit, display on/off, and display resolution.

1.11 FIRE AND SMOKE CONTROL SEQUENCES

A. Smoke Detection Interlock

1. Floor Damper Initiated Smoke Control

(a) When the smoke detector on any floor detects smoke, the following shall occur:

(1) The main supply and return fans shall continue to run;

(2) The main fan system return air damper(s) shall close;

(3) The outside air damper(s) shall open;

(4) The exhaust smoke damper on the smoke floor shall open;

(5) All other exhaust damper(s) shall close;

(6) Supply smoke damper(s) on floor above and floor below shall open;

(7) All other supply smoke damper(s) shall close; and

(8) All CAV or VAV supply boxes shall open to full open position.

2. Main Fan Initiated Smoke Control

(a) If smoke detectors at the main fans indicate smoke (which is unlikely since floor return should read smoke first), the return air damper will close, the outside air damper will open, the freezestats will by bypassed, the fans will continue to run on 100% makeup and 100% spill. All floor dampers will remain open. If floor return subsequently reads smoke, the above sequence of floor damper initiated smoke control will be initiated.

3. If smoke is detected during unoccupied cycle with fans off the above sequence will be activated and fans shall be started automatically.

B. Manual Smoke Purge Override – Panel Located in the Fire Command Center:

1. Provide manual means at fire command station, or at location required by code, to start and stop return fan and/or supply fan to achieve 100% exhaust and/or 100% make-up. In this cycle, the supply fan discharge air damper must be wide open, as sensed by an end switch, before the supply fan starts.

2. The BMS Fire Control Panel by BMS contractor shall be provided with on/off/auto toggle switches for over riding control of main HVAC system return/exhaust fans, network and electrical room fans, and tug tunnel fans. The switches shall override normal BMS operations as required by the Fire Department. For each mechanical fan, provide a relay energized by the BMS fire panel. Refer to the electrical drawings to determine the location

of the panel. When energized, the relay will open the respective associated F/S and exhaust dampers and close the respective return air damper associated with the return fan. A “smoke” position will permit manual start of return air fan. The freezestat and emergency shutdown shall be overridden. For systems with variable volume return fans, VFD shall be set to minimum when return fan starts. Provide a manual gradual switch near the return fan restart switch to permit control of VFD on return fan. A firestat at inlet to return fan will be provided to act as override, on manual operation of return air fan, to stop fan if temperature exceeds 125°F. Provide two single pole double throw end switches on exhaust damper and on intake damper to prevent respective fan start when dampers are indexed to 100% exhaust on supply positions.

3. Fire Alarm Panel Shutdown of Exhaust Fans

(a) Upon a signal from the fire alarm panel (by and coordinatd with electrical contractor), all exhaust fans shall shut down. BMS contractor shall coordinate all exhaust fan wiring and/or controls with the fire alarm panel contractor.

C. Electric/Communications Rooms

1. When a fire alarm on the floor is activated, the smoke damper to each electric/communications room shall be closed by the fire alarm system (FAS). When smoke exhaust is required, the FAS shall reopen the dampers, open the floor general exhaust and smoke exhaust dampers and start the smoke exhaust fan. Provide interconnecting wiring and/or tubing, EP relays, etc. as required.

D. Return Fan Used For Smoke Exhaust

1. Fans with smoke detectors shall stop upon the presence of smoke through the FAS system (except in smoke exhaust mode).

2. The fire alarm system shall start the return fan in smoke mode whenever smoke exhaust is required. All interlocked dampers shall open and close with fan operation. Common dampers shall open as required to allow exhaust airflow during smoke exhaust mode. Air handling unit return air dampers shall remain closed and exhaust/relief dampers shall remain open during smoke exhaust.

PART 2 - PRODUCTS

(Not Applicable)

PART 3 - EXECUTION

(Not Applicable)

END OF SECTION 15951

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 15990 - TESTING, BALANCING AND ADJUSTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of Air Systems.

B. Testing, adjusting, and balancing of Hydronic and Steam Systems.

C. Measurement of final operating conditions of HVAC Systems.

D. Sound measurement of equipment operating conditions.

E. Vibration measurement of equipment operating conditions.

F. Measurement of the IAQ after the completion of the final balancing.

1.2 SCOPE OF WORK:

A. General:

1. Testing, adjust and confirm design airflows rates, pressure drops, pressures, temperatures and heat transfer performance for HVAC systems, including, but not limited to chilled water system, condenser water system, steam and condensate system, hot water heating system, supply air, return air and exhaust air systems, including all associated pumps, heat exchangers, coils, fans, dampers, diffusers, terminal devices, fume hoods, valves and accessories, cooling towers, boilers, chillers, etc.

2. Provide all necessary labor, materials, products, equipment and services to balance and test all HVAC systems, to verify conformance to specified quantities, and to the design intent of the mechanical system and for the testing of all the fire safety systems.

3. Cooperate with all other trades, including, but not limited to, building controls, fire alarm, sheetmetal and piping sub-contractors to ensure the Work is carried out without interference to other Work.

4. Provide openings required for pitot tube traverses. After balancing, close openings with removable gasketed plugs. Submit samples of proposed plugs for approval.

5. Conduct routine inspections during the mechanical systems installation and report on poor ductwork installation (likely to produce abnormal leakage), poor piping installation, poor placement of dampers or valves, and any circumstance which will encumber the balancing of the mechanical systems.

6. Review Drawings and Specifications and ensure that adequate provisions are made in the mechanical installation to facilitate the balancing of all air, steam and water systems; make recommendations to the Architect/Engineer where additional measures may be required.

7. Include all items of labor, materials, products, equipment and devices required to comply with such standards and codes in accordance with the contract documents to balance all air and hydronic systems, to verify conformance to specified quantities and to the design intent of the mechanical system. Where quantities, sizes or other requirements indicated on the drawings or herein specified are in excess of the standard or code requirements, the specifications and drawings shall govern.

1.3 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification sections, apply to work of this section

B. This section is a part of each Division 15000 Section making reference to Testing, Balancing and Adjusting and the other sections of Division 15.

1.4 REFERENCES:

A. ASHRAE - Standard 111 - 1988 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.

B. ASHRAE - 1987 HVAC Systems and Applications Handbook: Chapter 57, Testing, Adjusting and Balancing.

C. AABC- National Standards for Total System Balance.

D. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental System.

E. SMACNA - HVAC System Testing, Adjusting and Balancing.

F. Sheet Metal Industry - Certification of Testing, Adjusting and Balancing Technicians.

1.5 DEFINITIONS

A. Systems testing, adjusting, and balancing is the process of checking and adjusting all the building environmental systems to produce the design objectives. It includes:

1. the balance of air, steam and hydronic distribution;

2. adjustment of total system to provide design quantities;
verification of performance of all equipment and automatic controls;

3. sound and vibration measurement.

4. IAQ measurements

B. Test: To determine quantitative performance of equipment.

C. Adjust: To regulate the specified fluid flow rate and air patterns at the terminal equipment (e.g., reduce fan speed, throttling).

D. Balance: To proportion flows within the distribution system (submains, branches, and terminals) according to specified design quantities.

E. Procedure: Standardized approach and execution of sequence of work operations to yield reproducible results.

F. Report forms: Test data sheets arranged for collecting test data in logical order for submission and review. These data should also form the permanent record to be used as the basis for required future testing, adjusting, and balancing.

G. Terminal: The point where the controlled fluid enters or leaves the distribution system. These are supply inlets on water terminals, supply outlets on air terminals, return outlets on water terminals, and exhaust or return inlets on air terminals such as registers, grilles, diffusers, louvers, and hoods.

H. Main: Duct or pipe containing the system's major or entire fluid flow.

I. Submain: Duct or pipe containing part of the systems' capacity and serving two or more branch mains.

J. Branch main: Duct or pipe serving two or more terminals.

K. Branch: Duct or pipe serving a single terminal.

1.6 SUBMITTALS:

A. Procedures: Furnish submittals in accordance with the general requirements of the Contract Documents.

B. Bid Submittals: Submit with bid, proposed balancing procedure on a system by system basis.

C. Activity Programs: The Air and Water Balance contractor shall prepare and submit for approval a detailed activity program. The program shall be in accordance with the overall Construction Schedule.

1. Specific requirements included within the activity program shall be:

(a) Required dates for the acceptance of system/equipment from the installing contractor "ready for balance".

(b) Required Periods for the individual system balancing.

(c) Requirements for attendance from the installing contractor and their suppliers.

2. Activity Programs shall be prepared for each major system and/or specific item of equipment.

3. Activity Programs shall include, but shall not be limited to the following:

   (a) Heating Water Piping System including:

      (1) Pumps

      (2) Boilers and/or heat exchangers

      (3) AC units - heating coils

      (4) Perimeter radiation

   (b) Chilled Water Piping System including:

      (1) Pumps

      (2) Chillers

      (3) Air Handling Units - Cooling Coils

   (c) Individual Air Handling Units including:

      (1) Fans (Supply, Return/Exhaust)

      (2) Coils (Cooling, heating and snow melting)

      (3) Outside air, return air and spill air dampers

      (4) Air Distribution Systems

   (d) Tug Tunnel Ventilation Systems

   (e) General Exhaust System

   (f) Specialized Ventilating Systems:

      (1) Elevator equipment rooms

      (2) Electric rooms

      (3) Computer Rooms

      (4) Supplementary AC Systems

   (g) Toilet Exhaust System

   (h) Steam Humidification System

   (i) All other air handling and exhaust systems as indicated on the drawings

D. Progress Reports: Submit progress reports on a system by system basis, including preliminary recommendations; allow for one such progress report, per system, prior to issue of final report. Progress report shall be issued upon notification by the Architect/Engineer shall be turned around within 10 working days.

E. Certified Test Reports: Furnish test results and a schematic layout for each system, certified by the Contractor. Six completed copies including schematic layouts, shall be submitted to the Owner. Balancing report submitted shall list each VAV/ CV box, grille, register and diffuser associated with each system, giving numerical identification (including room number or area name), design quantity, final quantity, etc., and design power requirements for all supply and exhaust fans and actual operating conditions listing RPM, volts, amps, kw, etc., in accordance with AABC/NEBB test report forms. Include identification and types of instruments used and their most recent calibration date with test reports.

1. General

(a) Provide a complete balancing report in 3-ring binder manuals. Report should include contents, page and index tabs and cover identification at front and side.

(b) Include types, serial number and dates of calibration of test instruments. (Submit calibration certificates).

(c) Record test data on a sepia made from the latest available revised set of mechanical drawings and submit six (6) copies upon completion of the balancing contract.

(d) Install at each piece of mechanical equipment a "Data Register" showing significant operating temperatures, pressures, amperes, voltage frequency, motor KW, FLA, belt size/model number and sheave size. "Data Register" to be enclosed in a plastic holder securely attached to the equipment or to a wall in the adjacent area.

(e) Submit with report, fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.

(f) Submit with the report schematics of all the air and water systems. The schematics should include the following:

F. Report Data

1. Duct Air Quantities - Mains, Branches, Outside Air, Return Air and Exhausts (Maximum and Minimum):

(a) Duct sizes (clear inside dimension)

(b) Number of pressure readings

(c) Sum of velocity

(d) Average velocity

(e) Duct recorded air flow rate

(f) Duct design air flow rate

(g) Provide data with system schematic

2. Air Inlet and Outlets:

(a) Outlet identification location and designation

(b) Manufacturer's catalogue identification and type

(c) Application factors

(d) Design and recorded velocities

(e) Design and recorded air flow rates

(f) Deflector vane of diffuser cone settings

(g) Provide data with system schematic

(h) Static Pressure upstream of terminal device.

3. Building Pressurization Data:

(a) Outside air temperatures

(b) Outside wind velocity

(c) Building pressures plotted with respect to systems
(d) Supply air, return and exhaust air flow rates

(e) Locations of pressure measuring points, inside and outside building

4. Pumps

(a) Installation Data:

(b) Design Data:

(c) Recorded Data:

5. Expansion Tank Data:

(a) Manufacturer, size, capacity and type

(b) Pressure reducing valve setting

(c) Pressure relief valve setting

(d) Expansion tank pressure reading

6. Air Heating and Cooling Equipment

   (a) Equipment Installation Data:

   (b) Equipment Design Data:

   (c) Equipment Recorded Data:
      (1) Element type and identification (location and designation)

      (2) Entering and leaving water temperatures

      (3) Entering steam pressure

      (4) Water pressure drop across HX

      (5) Water pressure drop across control valves

      (6) Steam pressure drop across control valves

      (7) Adjusted temperature rise or drop

7. Emergency Generator Ventilation
   (a) Generator manufacturer, model and Capacity

   (b) Design air flow at 100% outside air

   (c) Measured air flow at 100% outside air

   (d) Air temperature of inlet Louver

   (e) Air temperature at exhaust Louver

   (f) Room air temperature

8. Notice: Furnish written notification to the Owner's representatives 5 days prior to commencement of the work.

1.7 QUALITY ASSURANCE

A. Testing and Balancing Agency Qualifications:

1. Employ the services of an independent testing, adjusting, and balancing agency meeting the qualifications specified below, to be the single source of responsibility to test, adjust, and balance the building mechanical systems identified above, to produce the design objectives. Services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

2. The independent testing, adjusting, and balancing agency shall be certified by the National Environmental Balancing Bureau (NEBB) or Associated Air Balance Council (AABC) in those testing and balancing disciplines required for this project, and having at least one Professional Engineer registered in the State in which the services are to be performed, certified by NEBB or AABC as a Test and Balance Engineer.

3. The air and water balance agency shall provide proof of having at least 5 years testing, adjusting and balancing experience, as well as having successfully completed at least five projects of similar size and scope.

4. The work must be performed by a Certified Testing, Adjusting and Balancing Technician who may be assisted by other TAB Technicians. The Certified Testing, Adjusting and Balancing Technician is responsible for:

   (a) Procedures to be followed

   (b) Accuracy of all testing

   (c) Integrity of recorded data

   (d) Entering all data and reporting any abnormal or notable conditions on the report forms

   (e) Initialing and dating each sheet

5. The General Section of the Balance Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.

6. Codes and Standards:

   (a) NEBB: "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

   (b) AABC: "National Standards For Total System Balance".

   (c) ASHRAE: ASHRAE Handbook, 1984 Systems Volume, Chapter 37, Testing, Adjusting, and Balancing.

7. Contractor's Quality Assurance Responsibilities: This Contractor is solely responsible for quality control of the Work. Comply with the general requirements of the contract.

B. IAQ Testing Agency Qualifications:

1. The testing and balancing agency shall employ the services of an independent IAQ testing agency to test the building air systems identified above, to produce an IAQ report.

2. In conjunction with the testing and balancing agency, the IAQ testing agency's services shall include checking installations for conformity to design, measurement and establishment of the fluid quantities of the mechanical systems as required to meet design specifications, and recording and reporting the results.

3. The independent testing agency shall be certified by a National entity jurisdiction in IAQ testing disciplines required for this project, and having at least one Professional Engineer registered in the State in which the services are to be performed.

4. The testing agency shall provide proof of having at least 5 years testing experience, as well as having successfully completed at least five projects of similar size and scope.

5. The work must be performed by a Certified Technician who may be assisted by other Technicians. The Certified Technician is responsible for:

   (a) Procedures to followed

   (b) Accuracy of all testing

   (c) Integrity of recorded data

   (d) Entering all data and any abnormal or notable conditions in report forms

   (e) Initialing and dating each sheet

6. The General Section of the Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.

1.8 HVAC CONTRACTOR RESPONSIBILITIES

A. Prepare each system for testing and balancing

B. Cooperate with the testing agencies, provide access to all work, equipment and systems.

C. Put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing. Operate systems and under conditions required for proper testing, adjusting, and balancing.

D. Notify Testing Agency's project manager, Owner and Engineer seven days prior to time system will be ready for testing, adjusting, and balancing. Project readiness shall include:

1. Systems are started and running (fans and pumps have been checked for proper rotation).

2. Permanent electrical power wiring is complete.

3. Verification that all ductwork is fabricated and installed as specified.

4. Ceilings are installed in critical areas where air pattern adjustment may be required. Access to balancing devices are provided.

5. All equipment and ductwork access doors are securely closed.

6. All balancing, smoke and fire/smoke dampers are installed and in full open positions.

7. All isolation and balancing valves are open and control valves are operational.

8. System installation is complete, with Controls and Instrumentation installed and fully operational.

E. Where fans (air handling units, supply fans, return fans, exhaust fans, etc.) are provided with variable pitch sheaves, HVAC Contractor shall adjust sheaves, as required, at no additional cost to the Owner, until desired Design Points (CFM and Static Pressure) are reached. If adjustment of the variable pitch sheaves is beyond the range of the sheaves, HVAC Contractor shall replace sheaves, as required, at no additional cost to the Owner, until the desired Design Points (CFM and Static Pressure) are reached. Where fans (air handling, supply, return, exhaust, etc.) Are specified with fixed ratio sheaves, HVAC Contractor shall replace sheaves with new sheaves, at no additional cost to the Owner until desired Design Points (CFM and Static Pressure) are reached. Where fans (air handling units, supply fans, return fans, exhaust fans, etc.) are of the vane axial type with adjustable vanes, HVAC Contractor shall, at no additional cost to Owner, adjust vanes as required until desired Design Points (CFM and/or Static Pressure) are reached.

F. All duct work etc. that is found to exceed the permissible leakage rates shall be immediately repaired by the HVAC contractor, at no additional cost and in a timely manner so as not to interfere with the progress of the work.

1.9 SEQUENCING AND SCHEDULING

A. Sequencing work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.

1.10 DRAWING AND CONSTRUCTION REVIEW

A. Perform a preconstruction review of the following documents:

1. Updated construction drawings

2. Contract specifications

3. Addenda

4. Submittal data

5. Shop drawings

6. Automatic Control drawings

B. Prepare a report of the preconstruction review list of recommended changes to allow most effective balancing.

C. Perform four construction reviews of the mechanical installation during the progress of the project. Purpose of the reviews to be:

1. Identify potential problems for performing balancing.

2. Identify modifications which will aid balancing.

3. Schedule and coordinate balancing with other work and other trades.

D. Prepare a report of each construction review.

E. Pre-Balancing Conference: Prior to beginning of the testing, adjusting, and balancing procedures, schedule and conduct a conference with the Architect/Engineer and representatives of installers of the mechanical systems. The objective of the conference is final coordination and verification of system operation and readiness for testing, adjusting, and balancing.

1.11 PROJECT/SITE CONDITIONS:

A. General: Do not proceed until systems requiring testing, adjusting and balancing are clean and free from debris, dirt, and discarded building materials.

B. Air balance and testing shall not begin until system has been completed and is in full working order. The mechanical contractor shall put all heating, ventilating and air conditioning systems and equipment into full operation and shall continue the operation of same during each working day of testing and balancing.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. Provide all necessary testing, retesting, and balancing equipment including but not limited to instruments, gauges, blowers, tools, scaffolding, ladders, etc.

B. Provide all necessary instruments. Instruments shall be used and applied which are best suited to the system function being tested. Instruments shall be in first class state of repair and have been calibrated within a period of six months prior to starting the job. Calibration history of each instrument shall be available for examination. Instruments shall be re-calibrated upon completion of the job if required by the Design Engineer to prove reliability

2.2 SOURCE QUALITY CONTROL:

A. Test, calibrate, retest and recalibrate measuring instruments at the laboratory.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Before commencing work, verify that systems are complete and operable. Ensure the following:

1. Equipment is operable and in safe and normal condition.
2. Temperature control systems are installed complete and operable.
3. Proper thermal overload protection is in place for electrical equipment.
4. Pre and final filters are clean and in place. If required, install temporary media in addition to final filters.
5. Duct systems are clean of debris.
6. Correct fan rotation.
7. All fire, fire/smoke and volume dampers are in place and are in the full open position.
8. Coil fins have been cleaned and combed.
9. Access doors are installed and closed and duct end caps are in place.
10. Terminal devices and air outlets are installed, connected and accessible and adjusted for full maximum flow.
11. Duct system leakage has been minimized. All duct systems requiring Leakage Tests have been tested and accepted.
12. Proper strainer baskets are clean and in place.
13. Correct pump rotation.
14. Hydronic systems have been flushed, filled, and vented.
15. Service and balance valves are open.

B. Report to Architect/Engineer any defects or deficiencies noted during performance of services.

C. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.

D. If, for design reasons, system cannot be properly balanced, report as observed.

E. Beginning of work means acceptance of existing conditions.

3.2 PREPARATION

A. Provide instruments required for testing adjusting and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.

3.3 INSTALLATION TOLERANCES

A. Adjust Air Handling Systems to the following tolerances:

1. Supply systems shall be balanced so that:

(a) The total quantity to each space is within - 5% to + 10% of design values.

(b) If two outlets in space, each outlet is within - 10% to +10% of design value.

(c) If three or more outlets in space, each outlet is within -15% to +15% of design value.

2. Exhaust and return systems shall be balanced so the total quantity from each space is -10% to +10% of design values.

B. Adjust Hydronic Systems to the following tolerances:

1. Heating System (See Plans):

(a) Supply water temperature 80°F to 120°F: 0% to +10% of design value.

(b) Supply water temperature 120°F to 160°F: -5% to +10% of design value.

(c) Supply water temperature above 160°F: -10% to +10% of design value.

2. Cooling System (See Plans:

(a) Supply water temperature above 55°F: 0% to +10% of design value.

(b) Supply water temperature 45°F to 55°F: -5% to +10% of design value.

(c) Supply water temperature below 45°F: -10% to +10% of design value.

3.4 ADJUSTING

A. Recorded data shall represent actually measured or observed condition.

B. Permanently marked settings of valves, dampers, and other adjustment devices, allowing settings to be restored. Set and lock memory stops.

C. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.

D. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

3.5 WELDING INSPECTION:

A. Visual Inspection: Perform in accordance with Industry Standards. Cut out and test defective welds. If the percentage of defective welds is excessive, cut out and test additional welds as directed by Architect/Engineer.

3.6 VERIFICATION OF CONTROL OPERATION

A. General: Perform the checks outlined in the following for all air system controls:

1. Thermostats and humidistats - Verify calibration and operation of all thermostats and humidistats. Any Deficiencies shall be reported for correction. Recheck after correction. Record thermostat set point and output signal, space temperature.

2. Damper Operation - Verify operation and position for all dampers. Any Deficiencies shall be reported for correction. Recheck after correction.

3. Other Controls - Simulate control operations with control contractor in accordance with design requirements and manufacturer's recommendations. Any deficiencies shall be reported for correction. Recheck after correction.

3.7 OPERATING TESTS

A. General: After the various systems are pressure-tested and cleaned as hereinbefore specified, each piping and air handling system shall be tested in the presence of the Owner and Owner's representatives. Five days advance written notice of the tests shall be given to the Owner by the Contractor who in turn will notify other parties interested. Furnish all gauges, instruments, test equipment and personnel required for the tests. Adjust all equipment to perform with the least possible noise and vibration consistent with its duty. Quietness of operation of all equipment is a requirement. Any equipment producing objectionable noise in occupied spaces must be repaired or removed and replaced with satisfactory equipment.

B. Piping Systems: operate the cooling systems, and make adjustments in controls and equipment, and complete necessary balancing to deliver not less than the water quantities shown on the drawings at each equipment item.

C. NC (Noise Criteria) Tests: Operate the air handling systems after balancing, to determine that the scheduled NC ratings in the spaces are not exceeded.

3.8 AIR, WATER AND STEAM BALANCING:

A. Performance Verification:

1. Within one year after completion of air and water balance work, the Owner may request recheck and verification of outlets, supply air fan, exhaust air fan, pump, and other equipment listed in test report. Provide technicians and instruments when making tests required during this period of time.

2. Put all heating, ventilating and air conditioning systems and equipment into full operation and continue operation during each working day of testing and balancing.

3. Perform all work necessary to complete testing and balancing of air and water systems, including but not limited to the following.

(a) Balance, adjust and test air-moving equipment and air distribution, supply, return, exhaust, spill and recirculation systems.

(b) Test condenser water pumps.

(c) Balance condenser water distribution system.

(d) Test chilled water pumps.

(e) Balance chilled water distribution system.

(f) Test hot water pumps.

(g) Balance hot water distribution system.

(h) Test the entering and leaving steam pressure -PRV's

(i) Test the entering steam pressures - Heating Coils

(j) Test the entering steam pressures - Humidifiers in air handling units.

(k) Submit for approval complete test and balance data upon completion of tests and balancing.

B. Balance Data Report Forms: Provide both design and actual conditions for each item listed. Reports are required for each air handling supply, exhaust/spill, and recirculation and water system. Include as a minimum the following data.

1. Supply Systems:

(a) Date

(b) System No. and location

(c) Fan model #, arrangement, class

(d) Fan motor RPM, pulley size

(e) Fan motor amperage

(f) Pressure drop across coils and filters (advise if coils are wet or dry)

(g) Fan suction static pressure

(h) Fan discharge (or plenum) static pressure

(i) Unit discharge static pressure (External)

(j) Compressor amperage

(k) Rated motor amperage, starter heater number and ampere rating

(l) Recirculated air flow (CFM)

(m) Outside air flow (CFM)

(n) Outside air conditions (DB and WB)

(o) Mixed air conditions (DB and WB)

(p) Return air conditions (DB and WB)
(q) Entering coil conditions (DB and WB)

(r) Leaving coil conditions (DB and WB)

(s) Fan discharge conditions (DB and WB)

(t) Main Supply duct (CFM and Static Pressure)

(u) Final adjusted percentage of design

2. Exhaust and Recirculation Systems:

(a) Date

(b) Fan model #, arrangement and class

(c) System number and location (corresponding supply fan system)

(d) Rooms or area served

(e) Fan motor RPM

(f) Motor amperage and starter heater number and amperage rating

(g) Rated motor amperage

(h) Fan inlet static pressure and temperature (DB & WB)

(i) Fan outlet static pressure and temperature (DB & WB)

(j) Final adjusted percentage of design

3. Room Data:

(a) Room number

(b) Supply and exhaust/return system number

(c) Supply at each diffuser (min. and max. for VAV systems)

(d) Return/Exhaust at each register or grille

(e) Air opening sizes and area factors

(f) Final adjusted percentages of each opening

4. Water Systems:

(a) Outdoor conditions at time of test (DB & WB)

(b) Pump name and number (mfg., model #, type)

(c) Pump RPM

(d) Pump amperage (individual operation)

(e) Pump amperage (multiple operation)

(f) Rated motor amperage, starter heater number and amperage rating.

(g) Pump inlet pressure (individual operation)

(h) Pump inlet pressure (multiple operation)

(i) Pump outlet pressure (individual operation)

(j) Pump outlet pressure (multiple operation)

(k) Flow (individual operations)

(l) Flow (multiple operations)

(m) Supply temperature

(n) Return temperature

(o) Flow at each heat exchanger (GPM, EWT, LWT and pressure drops)

(p) Flow at each air conditioning unit

(q) Flow at each flow measuring station

(r) Inlet and outlet temperature at each air conditioning units' coils (water conditions shall be recorded at same time as air temperature)

(s) Inlet and outlet pressure at each air conditioning unit

(t) Final adjusted percentage of design

5. Steam Systems:

(a) Outdoor conditions at time of test.

(b) PRV inlet and outlet pressures

(c) Heating Coils inlet pressures

(d) Humidifiers inlet pressures

C. Balancing Procedure:

1. Air Distribution Systems: Operate the air handling systems and make adjustments in the controls and equipment as required to balance the systems to deliver the required design air quantities and temperatures.

(a) Air Handling Systems:

(1) First set of air filters shall be in place whenever fans are run. Replace with clean set of specified filters before testing.

(2) Run supply fan with all dampers in their normal position (minimum outside air). Duplicate normal conditions as far as possible with clean filters in place, coils in operation, etc. Adjust for proper ratio of outside and return air.

(b) Note that VAV boxes are calibrated at factory. Nevertheless, recalibrate each VAV box in field as part of this work. Air balancer shall show two readings for each box, minimum and maximum and corresponding inlet and outlet static pressure.

(c) Note that fan powered mixing boxes are calibrated at factory. However, due to changing inlet conditions, recalibrate each mixing box in field as part of this work and provide reading for box (CFM) (M^3/sec), and primary air at maximum and minimum setting and corresponding inlet and outlet static pressure.

(d) NC (Noise Criteria) Tests: Operate the air handling systems after balancing, to determine that the schedule NC ratings in the spaces are not exceeded.

NOTE: All volume dampers and VAV boxes shall be positioned for maximum air flow before taking initial supply airflow and static pressure readings. Advise Engineer immediately if design airflows of air handling units are not achieved before proceeding with further testing.

(e) Test and adjust fan RPM to design requirements.

(f) Test and record motor load in amperages at various filter percentages.

(g) Make pitot tube transverse of main supply ducts. Obtain design air flow at 50 percent dirty filter condition.

(h) Test and adjust systems for design recirculated air flow .

(i) Test and record system static pressures suction and discharge.

(j) Test and adjust systems for design outside air.

(k) Test and record entering air temperatures (DB & WB).

(l) Test and record leaving air temperatures (DB & WB).

(m) Adjust main supply and return air ducts to proper design air flow.

(n) Test and adjust each diffuser, grille and register to within percentage of design requirements as detailed above.

(o) Adjust all zones to proper design CFM, supply and return. VAV devices (boxes) shall be tested for minimum and maximum flow.

(p) Identify each VAV terminal device, grille, diffuser and register as to locations and area.

(q) Size, type, factors, and manufacture of diffusers, grilles, registers, and tested equipment shall be identified and listed. Use Manufacturer's ratings on equipment to make required calculations.

(r) Readings and tests of diffusers, grilles, and registers shall include required velocity and test resultant velocity, required air flow and test resultant air flow after adjustments.

(s) Set and adjust automatically operated dampers to operate as specified, indicated, and/or noted. Check controls for proper calibration and list controls requiring adjustment.

(t) Adjust diffusers, grilles, and registers to minimize drafts.

(u) Test filter manometer and set tap at maximum pressure drop.

2. AC Units

(a) During balancing of the AC units ensure that outdoor air, general exhaust and toilet exhaust systems are operating at their design levels.

(b) Adjustment and balancing of the AC units will require close coordination with the mechanical and building controls contractors to ensure desired operation sequence and performance are achieved.

(c) Some of the AC units have been provided with variable frequency inverter drives, which should facilitate the balancing operation.

(d) Test and adjust fan RPM to design requirements. Ensure that design volume flow rates and static pressure are achieved at branch outlets.

(e) Verify correct fan rotation.

(f) Test and record motor load in amps at various flow rate percentages.

(g) Make pitot tube traverses of main supply ducts to determine fan delivery. Obtain design air flow at 50% dirty filter condition (simulate).

(h) Repeat for 90%, 80% and 70% of design flow, at constant design static pressures.

(i) Measure and record supply air temperature (WB & DB) and return air temperature (WB & DB).

(j) Measure Total Static Pressure and discharge static pressures at branch outlets for each flow condition.

(k) Measure outdoor air volume and return air volume through the outdoor air damper and room return air opening respectively, for each flow condition.

(l) Measure and record chilled water entering and leaving temperatures.

3. Outdoor Air Supply Systems:

(a) Note: Outdoor air supply systems must be balanced with General Exhaust and Toilet Exhaust systems operating at their design levels.

(b) Test and adjust fan RPM to design requirements.

(c) Verify correct fan rotation.

(d) Test and record motor load in amps in various flow rate percentages.

(e) Make pitot tube traverses of main supply ducts to determine fan delivery. Measure design flow at 50% dirty filter condition (simulate).

(f) Measure the static pressure profile of the air handling unit and system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(g) Adjust and balance the motorized fresh air dampers in each MER or at each AC unit to obtain design flow. Dampers are two position, thus requiring adjustment of damper blade positioning linkage in the open position.

(h) After adjustments to dampers throughout the system have been made, re-check fan performance adjusting as necessary.

(i) Mark all damper settings.

4. General Exhaust Systems:

NOTE: Corresponding supply air systems shall be operating at their design levels during testing and balancing procedures.

(a) Test and adjust fan RPM to design requirement.

(b) Verify correct fan rotation.

(c) Test and record motor load in amps, at various flow rate percentages.

(d) Make pitot tube traverses of main exhaust ducts to determine fan delivery. Obtain design flow , make adjustments as necessary.

(e) Measure the system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(f) Adjust and balance manual and motorized general exhaust air dampers on each floor level to obtain design air flow. Automatic dampers are of the two position type, thus requiring adjustment of damper blade positioning linkage in the open position.

(g) After adjustments to dampers throughout the system have been made, re-check fan performance, adjusting as necessary.

(h) Mark all damper settings.

5. Toilet Exhaust Systems

NOTE: Corresponding supply air systems shall be operating at their design levels during testing and balancing procedures.

(a) Test and adjust fan RPM to design requirements.

(b) Verify correct fan rotation.

(c) Test and record motor load in amps at various flow percentages.

(d) Make pitot tube traverses of main exhaust ducts to determine fan delivery. Obtain design flow, make adjustments as necessary.

(e) Measure the system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(f) Adjust and balance manual volume control dampers in exhaust ductwork to obtain design, at each register.

(g) Measure air volume supplied into toilet through each of the transfer grilles.

(h) After adjustments to toilet exhaust ductwork registers etc. have been made re-check fan performance, adjusting as necessary.

(i) Mark <u>all</u> damper settings.

6. Miscellaneous Exhaust Systems (Including Fume Hood)

NOTE: Corresponding supply air systems shall be operating at their design levels during testing and balancing procedures.

(a) Test and adjust fan RPM to design requirements.

(b) Verify correct fan rotation.

(c) Test and record motor load in amps at various flow percentages.

(d) Make pitot tube traverses of main exhaust ducts to determine fan delivery. Obtain design flow, make adjustments as necessary.

(e) Installed fume hood fans shall be adjusted to CFM requirements as shown on plans and as specified. Tests of fume hood enclosures shall be made to determine required velocities across opening.

(f) Measure the system duct static pressure at selected points (minimum of 10) throughout the system, including points along the vertical riser shafts.

(g) Adjust and balance manual volume control dampers in exhaust ductwork to obtain design, at each register.

(h) After adjustments to exhaust registers etc. have been made re-check fan performance, adjusting as necessary.

(i) Mark all damper settings.

7. Water Systems: Prepare water systems for balancing as follows.

(a) Operate the piping systems, and make adjustment in controls and equipment, and complete necessary balancing to deliver not less than the water quantities shown on the drawings at each equipment item. Balance all water systems regulated on a pressure drop and flow measurement basis.

(1) Phase I

(i) Piping Systems: Operate the cooling and heating, systems and make adjustments in controls and equipment, and complete necessary balancing to deliver not less than the water quantities shown on the drawings at each equipment item.

(ii) Open manual valves to full open position except valves intended to be normally closed during system operation.

(iii) The installing contractor shall remove strainers and clean in the presence of this contractor.

(iv) Examine water in system and determine if water has been treated and cleaned. Secure certification from the water treatment supplier.

(v) Check pump rotation.

(vi) Check expansion tanks to determine not air bound and ensure system is full of water.

(vii) Check air vents at high points of water systems to ensure they are installed and operating freely. Bleed air from manual vents.

(viii) Set temperature controls for AC units calling for full flow.

(ix) Check and set, in cooperation with temperature control manufacturer's representative, design condenser, chilled, heating water temperature.

(x) Complete air balancing before actual water balance begins.

(xi) Check operation of automatic bypass valve.

(xii) Measure and record flow (GPM), suction and discharge pressures. At pumps. Advise Engineer if design flows can not be achieved.

Perform ‘block-tight’ no-flow test and record data.

(2) Test and Balance Procedure - Phase II:

(i) After completion of Phase I, proceed with Phase II as follows.

(ii) Set chilled water, and hot water pumps to proper delivery.

(iii) Adjust flow of chilled water and heating water through each air conditioning unit and/or heat exchanger.

(iv) Check and record leaving water temperatures and return water temperatures of heat exchanger, cooling towers, free cooling coils, evaporators and condensers. Reset to correct design temperatures.

(v) Check and record water temperatures at inlet side of coils. Note riser or drop of temperatures from source. Record supply and return temperatures.

(vi) Balance each water coil.

(vii) Where 3-way valves are installed, bypass flow shall be adjusted to same flow as through coil or heat exchanger circuit.

(viii) Upon completion of flow readings and adjustments at coils, mark settings and record data.

(3) Test and Balance Procedure - Phase III:

(i) Upon completion of Phases I and II, proceed with Phase III as follows.

1) After adjustments to coils are made, recheck settings at pumps and heat exchanger and readjust if required.

2) Install pressure gages on coils, read pressure drop through AC unit at set flow rate on call for full cooling. Set pressure drop across bypass valve to match coil full flow pressure drop.

3) Record and check following items at each element.

a) Inlet water temperature.

b) Outlet water temperature.

c) Pressure drop of AC unit.

d) Pressure drop across valve.

e) Pump operating suction and discharge pressures and final total discharge head.

f) List mechanical specifications of pumps.

g) Rated and actual running amperage of pump motor.

h) Water metering device readings.

i) Wet and dry bulb outdoor temperatures.

(ii) Air temperature tests in Phase I of Balancing Procedure shall be repeated and recorded in this Phase.

D. Reports and Records: Include records of flow measurements made during testing and balancing work. Provide complete set of marked-up balancing plans with report. Plans shall show air opening numbers, and flow station numbers that correspond to numbering system in balancing logs.

E. After completion mark adjusted position of each balancing valve and damper for permanent reference.

F. Keep system in operation for period of five days during which time final inspection will be made by the Owner. After completion mark adjusted position of each balancing valve and damper for permanent reference.

3.9 INDOOR AIR QUALITY TESTING

A. Equipment Specification:

1. An infrared photo acoustic analyzer shall be used to monitor for carbon dioxide, carbon monoxide, and total volatile organic compounds levels. It is a real time analyzer equipment. The sampling installation in the building shall extend into the outside air, supply air and return air of each central HVAC system. In tenant areas the sampling points shall be as close as possible to the occupants breathing zones.

2. Calibration shall be performed in accordance with manufacturer specifications and recommended procedures.

B. Application (Analytical Methodology)

1. The analytical method used shall be a direct reading of the infrared spectroscopy technique, which classifies different organic compounds by their ability to absorb energy of specific wavelengths in the infrared region, specifically, center wavelength 3.4 µm and 3.6 µm respectively, as well as determine carbon dioxide and carbon monoxide in parts per million (ppm). The sub detection levels of the instrument, in parts per million (ppm) and milligrams per cubic meter (mg/m^3), shall be as follows:

   (a) Carbon dioxide ≈ 1.7 ppm;

   (b) Carbon monoxide ≈ 0.2 ppm;

   (c) Total volatile organic compounds, center wavelength 3.4 µm = 0.036 mg/m^3. The instrument is calibrated for propane at this wavelength. The detection level of this filter is sensitive to changes in relative humidity.

   (d) Total volatile organic compounds center wavelength 3.6 µm = 0.07 mg/m^3. The instrument is calibrated for formaldehyde at this wavelength.

C. Indoor Air Quality Periodic Testing - Tenant Space

1. Two different sampling strategies shall be used, time specific sampling and 24 hour Continuous Monitoring.

2. The first strategy shall be the collection of indoor gaseous air quality data from a floor at a specific point in time (known as Time Specific Sampling), providing a snapshot of ambient conditions which are to be compared to applicable indoor air quality standards for verification of compliance with operating parameters.

3. The second strategy (known as 24-Hour Continuous Monitoring) expands upon the first through the use of additional equipment and provides a 24-hour study of conditions on the floor. The enhanced data produced by this configuration provides a more comprehensive view of ambient conditions and can record transient conditions that occur any time during monitoring. A graphical representation of gas concentrations over the sampling period is provided as part of the report.

D. Time-Specific Sampling

1. Indoor Gaseous Air Quality Monitoring for carbon dioxide (CO_2), carbon monoxide (CO) and two classes of total volatile compounds (TVOC) utilizing air sampling and the Infra-red Photo acoustic Multi-Gas Analyzer shall be performed at 4 locations on each floor or every 10,000 feet, whichever is smaller as well as at the central HVAC equipment. This survey shall also include a visual inspection of the MER for parameters adversely affecting indoor air quality. The inspection should be focused on mechanical hygiene and should follow the parameters dictated by EPA's guidelines such as the "Building Air Quality: A Guideline For Building Owners and Facilities Managers".

2. 24-Hour Continuous Monitoring

(a) Continual monitoring of Gaseous Indoor Air Quality Parameters shall include: carbon dioxide (CO_2), carbon monoxide (CO) and two classes of total volatile organic compounds (TVOC). This monitoring shall be performed utilizing air sampling installations and Infra-red Photo-acoustic Multi-Gas Analyzer configured for continuous, unattended operation for a 24-hour period. This survey shall include a visual inspection of the MER for parameters adversely affecting indoor quality. The inspection should be focused on mechanical hygiene and should follow the parameters dictated by EPA's guidelines such as the "Building Air Quality' A Guideline For Building Owners and Facilities Managers".

END OF SECTION 15990

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SECTION 15991 - PLUMBING
TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes testing, adjusting, and balancing plumbing systems to produce design objectives, including the following:

1. Balancing hot water circulation flow within distribution systems, including submains and/or branches.
2. Measuring electrical performance of plumbing equipment.
3. Setting quantitative performance of plumbing equipment.
4. Verifying that automatic control devices are functioning properly.
5. Reporting results of the activities and procedures specified in this Section.

B. Related Sections include the following:

1. Testing and adjusting requirements unique to particular systems and equipment are included in the Sections that specify those systems and equipment.
2. Field quality-control testing to verify that workmanship quality for system and equipment installation is specified in system and equipment Sections.

1.3 DEFINITIONS

A. Adjust: To regulate fluid flow rate at the terminal equipment, such as to adjust balancing valves.

B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to design quantities.

C. Procedure: An approach to and execution of a sequence of work operations to yeald repeatable results.

D. Report Forms: Test data sheets for recording test data in logical order.

E. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.

F. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

G. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

H. System Effect Factory: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

I. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

J. Test: A procedure to determine quantitative performance of a system or equipment.

K. Testing, Adjusting, and Balancing: The entity responsible for performing and reporting the testing, adjusting, and balancing procedures.

1.4 SUBMITTALS

A. Quality-Assurance Submittals: Within 30 days from the Contractor's Notice to Proceed, submit 2 copies of evidence that the testing, adjusting, and balancing and this Project's testing, adjusting, and balancing team members meet the qualifications specified in the "Quality Assurance" Article below.

B. Contract Documents Examination Report: Within 45 days from the Contractor's Notice to Proceed, submit 2 copies of the Contract Documents review report as specified in Part 3 of this Section.

C. Strategies and Procedures Plan: Within 60 days from the Contractor's Notice to Proceed, submit 2 copies of the testing, adjusting, and balancing strategies and step-by-step procedures as specified in Part 3 "Preparation" Article below. Include a complete set of report forms intended for use on this Project.

D. Certified Testing, Adjusting, and Balancing Reports: Submit 2 copies of reports prepared, as specified in this Section, on approved forms certified by the testing, adjusting, and balancing Agent.

E. Sample Report Forms: Submit 2 sets of sample testing, adjusting, and balancing report forms.

F. Warranty: Submit 2 copies of special warranty specified in the "Warranty" Article below.

1.5 QUALITY ASSURANCE

A. Testing, Adjusting, and Balancing Conference: Meet with the Owner's and the Architect's representatives on approval of the testing, adjusting, and balancing strategies and procedures plan to develop a mutual understanding of the details. Ensure the participation of testing, adjusting, and balancing team members, equipment manufacturers' authorized service representatives, plumbing controls Installer, and other support personnel. Provide 7 days' advance notice of scheduled meeting time and location.

1.6 COORDINATION

A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, Plumbing controls installers, and other mechanics to operate plumbing systems and equipment to support and assist testing, adjusting, and balancing activities.

B. Notice: Provide 7 days' advance notice for each test. Include scheduled test dates and times.

1.7 WARRANTY

A. General Warranty: The national project performance guarantee specified in this Article shall not deprive the Owner of other rights the Owner may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by the Contractor under requirements of the Contract Documents.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Contract Documents to become familiar with project requirements and to discover conditions in systems' designs that may preclude proper testing, adjusting, and balancing of systems and equipment.

1. Contract Documents are defined in the General and Supplementary Conditions of the Contract.
2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

B. Examine approved submittal data of plumbing systems and equipment.

C. Examine project record documents described in Division 1 Section "Project Record Documents."

D. Examine Architect's and Engineer's design data, including plumbing system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about plumbing system and equipment controls.

E. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Specification Sections have been performed.

F. Examine system and equipment test reports.

G. Examine plumbing system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and properly installed, and their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

H. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

I. Examine strainers for clean screens and proper perforations.

J. Examine 3-way valves for proper installation for their intended function of diverting or mixing fluid flows (if required).

K. Examine open-piping-system pumps to ensure absence of entrained air in the suction piping.

L. Examine equipment for installation and for properly operating safety interlocks and controls.

M. Examine automatic temperature system components to verify the following:

1. Valves, and other controlled devices operate by the intended controller.
2. Valves are in the position indicated by the controller.
3. Integrity of valves for free and full operation and for tightness of fully closed and fully open positions.
4. Automatic modulating and shutoff valves, including 2-way valves and 3-way mixing and diverting valves, are properly connected (if required).
5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
6. Sensors are located to sense only the intended conditions.
7. Sequence of operation for control modes is according to the Contract Documents.
8. Controller set points are set at design values. Observe and record system reactions to changes in conditions. Record default set points if different from design values.
9. Interlocked systems are operating.

N. Report deficiencies discovered before and during performance of testing, adjusting, and balancing procedures.

3.2 PREPARATION

A. Prepare a testing, adjusting, and balancing plan that includes strategies and step-by-step procedures.

B. Complete system readiness checks and prepare system readiness reports. Verify the following:

1. Permanent electrical power wiring is complete.
2. Hydronic systems are filled, clean, and free of air.
3. Equipment access doors are securely closed.
4. Isolating and balancing valves are open and control valves are operational.

3.3 GENERAL TESTING AND BALANCING PROCEDURES

A. Mark equipment settings with paint or other suitable, permanent identification material, including valve indicators, and similar controls and devices, to show final settings.

3.4 FUNDAMENTAL PROCEDURES FOR HOT WATER CIRCULATIONSYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. Prepare systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

1. Open all manual valves for maximum flow.
2. Check expansion tank liquid level.
3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
4. Check flow-control valves for specified sequence of operation and set at design flow.
5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type, unless several terminal valves are kept open.
6. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
7. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.5 HOT WATER CIRCULATION SYSTEMS' BALANCING PROCEDURES

A. Determine water flow at pumps. Use the following procedures, except for positive-displacement pumps:

1. Verify impeller size by operating the pump with the discharge valve closed. Verify with the pump manufacturer that this will not damage pump. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on the manufacturer's pump curve at zero flow and confirm that the pump has the intended impeller size.

2. Check system resistance. With all valves open, read pressure differential across the pump and mark the pump manufacturer's head-capacity curve. Adjust pump discharge valve until design water flow is achieved.
3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on the pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
4. Report flow rates that are not within plus or minus 5 percent of design.

3.6 WATER HEATERS

A. Measure entering- and leaving-water temperatures and water flow.

3.7 TEMPERATURE-CONTROL VERIFICATION (MIXING VALVES)

A. Verify that controllers are calibrated and commissioned.

B. Check transmitter and controller locations and note conditions that would adversely affect control functions.

C. Record controller settings and note variances between set points and actual measurements.

D. Verify operation of limiting controllers (i.e., high- and low-temperature controllers).

E. Verify free travel and proper operation of control devices such as valve operators.

F. Verify sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water-flow measurements. Note the speed of response to input changes.

G. Confirm interaction of electrically operated switch transducers.
H. Confirm interaction of interlock and lockout systems.

I. Verify main control supply-air pressure and observe compressor and dryer operations.

J. Record voltages of power supply and controller output. Determine if the system operates on a grounded or nongrounded power supply.

K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.8 TOLERANCES

A. Set plumbing system water flow rates within the following tolerances:

1. Heating-Water Flow Rate: 0 to minus 10 percent.

3.9 REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article above, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to plumbing systems and general construction to allow access for performance measuring and balancing devices.

3.10 ADDITIONAL TESTS

A. Within 90 days of completing testing, adjusting, and balancing, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

END OF SECTION 15991

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SECTION 15995 - SPECIAL MECHANICAL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES:

A. Equipment as described.

1.2 RELATED DOCUMENTS:

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Section 15010 - Basic Mechanical Requirements

C. Section 15050 - Basic Mechanical Materials and Methods

D. This section is a part of each Division 15000 Section.

E. Division 16 - Electrical.

1.3 REFERENCES:

A. ANSI/ASTM C553 - Mineral Fiber Blanket and Felt Insulation.

B. ANSI/ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

C. ASTM E84 - Surface Burning Characteristics of Building Materials.

D. NFPA 255 - Surface Burning Characteristics of Building Materials.

E. UL 723 - Surface Burning Characteristics of Building Materials.

1.4 QUALITY ASSURANCE:

A. Applicator: Company specializing in equipment manufacturing of type specified.

1.5 SUBMITTALS:

A. Submit product data under provisions of Section 01300.

B. Include product description, and locations.

C. Submit manufacturer's installation instructions under provisions of Section 01300.

PART 2 - PRODUCTS

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2.1 DIESEL EMERGENCY GENERATOR-INTEGRAL RADIATOR:

A. Furnish and install support systems for emergency generator as follows.

1. Ductwork to attach engine radiator to building discharge louver.

2. Vent piping from day tank to outdoors with insect screen. Make-up air intake louvre and discharge air louvre.

3. Ductwork extension from make-up air louvre where required to supply air at end of generator set opposite to radiator end.

4. Spring return, normally closed non-modulating electric motorized dampers at radiator discharge and in air intake (to close when generator is not running).

5. Electric heaters and thermostats in generator room to maintain minimum temperature when engine is not running.

6. Diesel fuel storage tank.

7. Diesel fuel transfer system consisting of supply piping, overflow piping, duplex transfer fuel pumps, automatic alternator, solenoid valve in supply line close to tank to shut down when pump stops. Wiring will be provided so that lag pump starts if lead pump fails to deliver oil.

8. Exhaust pipe extension including installation of mufflers, flexible connection, and "through-wall" thimble.

B. The furnishing and installation of the following is not included in the HVAC work.

1. Emergency generator and switchgear.

2. Day-tank.

3. Wiring and control interlocks.

C. Diesel Oil Underground Tank(s)

1. Furnish and install cylindrical Fiberglas fuel oil storage tank(s) as specified under another section of this work.

D. Tank Gauges

1. Furnish and install on (each) Emergency Diesel Oil Tank, a liquid level gauge as selected under another section of this work.

E. Engine Exhaust System

1. Exhaust pipe shall be schedule 40 black steel, welded, from each engine exhaust manifold to a suitable weatherproof terminal on roof or where shown on plans. Pitch exhaust pipe away from engine and provide drain pocket and valve at low point. If riser height exceeds 15 ft. provide trap and valve in piping to collect condensate. The exhaust muffler and flexible piping connector will be furnished by another trade, and installed by this trade. Exhaust piping passing through walls, floor, or other space division shall pass through a welded steel thimble or other approved device to isolate the wall from exhaust heat.

2. The engine exhaust system & muffler shall be insulated with 3 inch calcium silicate molded insulation of eleven pound density, canvased where exposed.

F. Diesel Oil Transfer Pumps

1. Provide and install a duplex Diesel Fuel Transfer Pump as specified under another section of this work.

G. Fuel Oil Piping

1. Furnish and install a complete system of piping as specified under another section of this work.

2.2 GASEOUS FUEL EMERGENCY GENERATOR-INTEGRAL RADIATOR:

A. Furnish and install support systems for an emergency generator as follows.

1. Ductwork to attach engine radiator to building discharge louvre.

2. Ductwork extension from make-up air louvre where required to supply air at end of generator set opposite to radiator end.

3. Spring return, normally closed non-modulatory motorized dampers at radiator discharge and in air intake (to close when generator is not running).

4. Electric heaters and thermostats in generator room to maintain minimum temperature when engine is not running.

5. Exhaust pipe extension including installation of muffler, flexible connection, and "through-wall" thimble.

B. The furnishing and installation of the following is not included in the HVAC work.

1. Emergency generator and switchgear.

2. Wiring and control interlocks.

C. Engine Exhaust System

1. Exhaust pipe shall be schedule 40 black steel, welded, from each engine exhaust manifold to a suitable weatherproof terminal on roof or where shown on plans. The exhaust muffler and flexible piping connector will be furnished by another trade, and installed by this trade. Exhaust piping passing through walls, floor, or other space division shall pass through a welded steel thimble or other approved device to isolate the wall from exhaust heat.

2. The engine exhaust system & muffler shall be insulated with 3 inch calcium silicate molded insulation of eleven pound density, canvased where exposed.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Install as per Article 15050.

3.2 SCHEDULE:

A. As described on drawings or in Products.

END OF SECTION 15995

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 16050 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 16.

1.2 SUMMARY

A. This Section includes general requirements for electrical installations. These requirements are applicable to all Division 16 work. The following requirements are included in this Section to expand the requirements specified in Division 1:

1. Submittals.

2. Coordination drawings.

3. Record documents.

4. Maintenance manuals.

5. Rough-ins.

6. Electrical installations.

7. Cutting and patching.

8. Codes, Permits and Inspections.

9. Separation of Work Between Trades.

10. Definitions and Interpretations.

11. Energy Conservation Rebate Programs.

1.3 SUSTAINABLE DESIGN

A. Sustainable Design Intent: Comply with project requirements intended to achieve a Certified Rating, measured and documented according to the LEED Green Building Rating System, of the US Green Building Council.

B. LEED Certification Documentation: Submit documentation from the manufacturer highlighting LEED requirements for materials and products of this Section.

C. Comply with the requirements of Division 1 Section “LEED REQUIREMENTS”.

D. Construction Waste Management: Comply with the requirements of Division 1, Section “Construction Waste Management”, for removal and disposal of construction debris and waste.

1.4 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Section "SUBMITTALS."

B. Additional copies may be required by individual sections of these Specifications.

1.5 COORDINATION DRAWINGS

A. Prepare coordination drawings in accordance with Division 1 to a scale of 1/4"=1'-0" (1:50) or larger; detailing major elements, components, and systems of electrical equipment and materials in relationship with other systems, installations, and building components in spaces such as electric switchgear room, [emergency generator room,] [UPS room,] and electric closets. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of major raceway systems, equipment, and materials. Include the following:

(a) Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.

(b) Exterior wall and foundation penetrations.

(c) Fire-rated wall and floor penetrations.

(d) Equipment connections and support details.

(e) Sizes and location of required concrete pads and bases.

2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

3. Prepare floor plans, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

B. Project Coordination Drawings

1. This Trade shall add to Coordination Drawings prepared by the HVAC Contractor showing all of the electrical work (equipment, conduit, etc.) to be installed as part of the work of this section of the specifications.

2. Requirements for vibration isolation and seismic restraints shall be shown on the coordination drawings by each trade.

3. This Trade after showing all of the electrical work shall forward the completed reproducible Coordination Drawings to the General Contractor/Construction Manager.

4. The Electrical Contractor shall attend a series of meetings arranged by the General Contractor/Construction Manager to resolve any real or apparent interferences or conflicts with the work of the other Contractors.

5. The Electrical Contractor shall then make adjustments to his work on the Coordination Drawings to resolve any real or apparent interferences or conflicts.

6. After any real or apparent interferences and conflicts have been incorporated into the Coordination Drawings, the Electrical Contractor shall “sign-off” the final Coordination Drawings.

7. The Electrical Contractor shall not install any of this work prior to “sign-off” of final Coordination Drawings. If the electrical work proceeds prior to sign-off of Coordination Drawings, any change to the electrical work to correct the interferences and conflicts which result will be made by the Electrical Contractor at no additional cost to the project.]

1.6 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1. In addition to the requirements specified in Division 1, comply with the following:

1. A complete set of "as-built" or record electric drawings shall be made up and delivered to the Architect.

2. The drawings shall show:-

(a) All electric work installed exactly in accordance with the original design.

(b) All electric work installed as a modification or addition to the original design.

(c) The dimensional information necessary to delineate the exact location of all circuitry and wiring runs (other than lighting and appliance branch circuitry and small control, signal and communications runs) which are so buried or concealed as to be untraceable by inspection through the regular means of access established for inspection and maintenance.

(d) The numbering information necessary to correlate all electrical energy consuming items (or outlets for same) to the panel or switchboard circuits from which they are supplied.

3. The drawings shall be produced using AutoCAD software. The design drawing files will be made available should it be determined that such files would serve as suitable backgrounds for the "as-built" drawings. These documents remain the property of Cosentini Associates and may be used for no other purpose without expressed, written consent. The contractor shall assume all liabilities resulting from unauthorized use or modifications to the drawings.

4. "As-built" information shall be submitted as follows:
   (a) CADD drawing files on CD-R in AutoCAD format.
   (b) One (1) set of reproducible drawings.
   (c) Two (2) sets of blueprints.

5. The quantity of design drawings which are made available shall in no way be interpreted as setting a limit to the number of drawings necessary to show the required "as-built" information.

6. Progress prints of record drawings shall be submitted monthly during the construction period for Architect's approval.

1.7 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for major equipment items such as engine generator set(s), UPS equipment, alarm system(s), communications systems, transformers, busways, switchgear, switchboards, panelboards, automatic transfer switches, lighting fixtures, and other items as specified elsewhere.

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.

2. Manufacturer's printed operating procedures include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping,

shutdown, and emergency instructions.

3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.

4. Servicing instructions.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

1.9 CODES, PERMITS AND INSPECTIONS

A. All work shall meet or exceed the latest requirements of all national, state, county, municipal, and other authorities exercising jurisdiction over electrical construction work and the project.

B. All required permits and inspection certificates shall be obtained, paid for, and made available at the completion of the work.

C. Any portion of the work which is not subject to the requirements of an electric code published by a specific authority having jurisdiction shall be governed by the National Electrical Code and other applicable sections of the National Fire Code, as published by the National Fire Protection Association.

D. Equipment, material, layout and installation provided as part of the electrical work shall conform to the requirements of all agencies having jurisdiction. Include as part of the electrical work all required filings and submissions for approval. Equipment furnished separate from - but installed as part of - the electrical work, which does not have all necessary approvals, shall not be installed until approvals are obtained by the parties furnishing the equipment.

E. Installation procedures, methods and conditions shall comply with the latest requirements of the Federal Occupational Safety and Health Administration (OSHA).

F. All equipment furnished as part of the electrical work shall comply with the latest editions of all applicable state and municipal “energy codes.” Provide certification from the equipment suppliers for all energy-consuming equipment that the equipment fully complies with these codes. Equipment submissions will not be accepted for review unless accompanied by such certification in writing.

1.10 GUARANTEES AND CERTIFICATIONS

A. All work shall be guaranteed to be free from defects. Any defective materials or workmanship as well as damage to the work of all trades resulting from same shall be replaced or repaired as directed for the duration of stipulated guaranteed periods.

B. The duration of guarantee periods following the date of beneficial use of the system shall be one year. Beneficial use is defined as operation of the system to obtain its intended use.

C. The date of acceptance shall be the date of the final payment for the work or the date of a formal notice of acceptance, whichever is earlier.

D. Non-durable items such as electric lamps, shall be replaced up to the date of acceptance, such that they shall have had no more than 100 hours use prior to this date.

E. Certification shall be submitted attesting to the fact that specified performance criteria are met by all items of electrical equipment for which such certifications is required.

1.11 SEPARATION OF WORK BETWEEN TRADES

A. The specifications for the overall construction delineate various items of work under separate trade headings. The list below sets forth this delineation to the extent that it affects the electric work.

B. In the absence of more detailed information, the list shall be taken as a specific instruction to the electrical trade to include the work assigned to it.

C. Indications that any trade is to perform an item of work means that it is to perform the work for its own accommodation only, except as specifically noted otherwise.

Oth	=	Other than electrical or mechanical.
Plb	=	Plumbing
FP	=	Fire Protection
Htg	=	Heating, Ventilating & Air Conditioning
Elec	=	Electrical.
f	=	Furnished.
i	=	Installed.

p = Provided (furnished and installed).

Item	Oth	Plb	FP	Htg	Elec	Note
Motors for mechanical equipment.		p	p	p		
Motor controllers for: Htg Plb FP		 f 	 f	 f 	 i i 	Specifications and drawings delineate exceptions. Includes motor control centers if applicable.
Motor control devices for: Htg Plb FP		 p 	 p	 p 		Specifications and drawings delineate exceptions. Control devices for mounting within controller are provided integral with controller.
Power wiring for motors: Htg Plb FP					 p p 	
Control wiring for motor controllers: Htg Plb FP				 p 	 p p	Specifications and drawings delineate exceptions.
Temporary light and power.	p					See General conditions specifications. To accommodate all trades.

Item	Oth	Plb	FP	Htg	Elec	Note
Temporary water.	p					
Temporary heat.	p					
Temporary toilets.	p					
Hoisting.					p	
Rigging.					p	
Bracing and dunnage for safe rigging.					p	
Cutting, chasing and patching.	p					Cost where due to late installation or improper coordination of work is the responsibility of the electric.
Framed slots and openings in walls, decks and slabs.	p					Coordination drawings are required from the electric.
Sleeves through non-waterproof slabs, decks and walls.					p	Includes drilling of holes when required.
Sleeves through waterproof slabs, decks and walls.					p	Includes drilling of holes for other than field poured concrete.
Waterproof sealing of sleeves through waterproof slabs, decks and walls.					p	
Fireproof sealing (fire-stopping) excess opening spaces in slabs, decks and fire-rated walls.					p	
Excavation and backfill inside buildings.	p					
Excavation and backfill outside buildings.					p	
Concrete encasement of conduits.					p	Red coloring for concrete encasing primary voltage runs included in electric.

Item	Oth	Plb	FP	Htg	Elec	Note
Electric manholes and handholes.					p	Furnishing of covers, associated frames and other hardware included in electric.
Fastenings.					p	
Supports.					p	
Flashing of electric conduits through roof (pitch pockets).	p					
Concrete foundations, pads and bases inside buildings.	p					Furnishing of anchors and vibration mounts included in the electric.
Concrete foundations, pads and bases outside buildings.					p	Furnishing of anchors and vibration mounts included in the electric.
Concrete lined trenches in building foundation.	p					
Field touch-up painting of damaged shop coats.					p	
Field rustproof painting of supporting steel members, frames and racks.					p	
Finish painting of exposed work.	p					Red coloring of exposed fire protection alarm systems circuitry included in electric. Red and white striping of exposed primary voltage runs included in electric.
Finished wall and ceiling access doors, panels and supporting frames.	i				f	Supplying list of locations where required included in electric.
Permanent catwalks to equipment.	p					Supplying list of locations where required included in electric.

Item	Oth	Plb	FP	Htg	Elec	Note
Permanent ladders to equipment.	p					Supplying list of locations where required included in electric.
Opening frames for ceiling recessed lighting fixtures and other electrical items.					p	
Luminous ceilings.	p					Lamp strips and lamps included in electric.
Electric duct heaters (heaters installed in air ducts).				p		Line and control connections included in electric.
Electric heaters with integral fans, (unit heaters, cabinet heaters, fan coil units and the like.)				p		Line and control connections included in electric.
Electric radiators (baseboard, sill line and convector type heaters).					p	
Electric water heaters.		p				Line and control connections included in electric.
Electric boilers.				p		Line and control connections included in electric.
Through wall sleeve type air conditioning and electric heating units.					p	
Electric heater cables for radiant space heating.					p	
Electric heater cables for snow melting.					p	
Electric heater cables for mechanical system pipe tracing.					p	

Item	Oth	Plb	FP	Htg	Elec	Note
Electric power consuming items and controls for same not referred to above.	p	p	p	p		Line and control connections to equipment included in electric.
Rubbish removal.					p	Removal of the shipping and packing materials of electrical items is included in the electric regardless by whom the items are furnished.
Special tools for maintenance of equipment furnished as part of electric work.					f	

D. Include in the electrical work all necessary supervision and the issuing of all coordination information to any other trades who are supplying work to accommodate the electrical installations.

E. For items of equipment which are to be installed but not purchased as part of the electrical work, the electrical work shall include:

1. The coordination of their delivery.

2. Their unloading from delivery trucks driven in to any point on the property line at grade level.

3. Their safe handling and field storage up to the time of permanent placement in the project.

4. The correction of any damage, defacement or corrosion to which they may have been subjected.

5. Their field make-up and internal wiring as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage, supporting members, and fastenings necessary to adapt them to architectural and structural conditions.

7. Their connection to building wiring including the purchase and installation of all "crown boxes" or other type of termination junction boxes necessary to adapt and connect them to this wiring. Included also shall be the purchase and installation of any substitute lugs or other wiring terminations as may be

necessary to adapt their terminals to the building wiring as called for and to the connection methods set forth in these specifications.

F. Items of equipment which are installed but not purchased as part of the electrical work shall be carefully examined upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of the electric work will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The electric work includes all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.12 DEFINITIONS AND INTERPRETATIONS

A. As used in the drawings and specifications for electrical work, certain non-technical words shall be understood to have specific meanings as follows regardless of indications to the contrary in the General Conditions or other documents governing the electric work.

"Furnish" -- Purchase and deliver to the project site complete with every necessary appurtenance and support, all as part of the electrical work. Purchasing shall include payment of all sales taxes and other surcharges as may be required to assure that purchased items are free of all liens, claims or encumbrances. Payment of sales taxes is, however, specifically excluded.

"Install" -- Unload at the delivery point at the site and perform every operation necessary to establish secure mounting and correct operation at the proper location in the project, all as part of the electrical work.

"Provide" -- "Furnish" and "install."

"New" -- Manufactured within the past two years and never before used.

Regardless of their usage in codes or other industry standards, certain words as used in the drawings or specifications for the electrical work, shall be understood to have the specific meanings ascribed to them in the following list:-

"Circuitry" -- Any electric work (not limited to light and power distribution) which consists of wires, cables, raceways, and/or specialty wiring method assemblies taken all together complete with associated junction boxes, pull boxes, outlet boxes, joints, couplings, splices and connections except where limited to a lesser meaning by specific description.

"Wiring" -- Same as Circuitry.

"Circuit" -- Any specific run of circuitry.

"Branch Circuit" -- Any light and power distribution system circuit which, at its load end, is directly connected to one or more electrical energy consuming items with no overcurrent protection devices interposed, other than (where required) those protecting the energy consuming items from overloading or overheating.

"Appliance Panel" -- Any panel, used in a light and power distribution system, containing single pole and/or multipole branches rated in various sizes.

"Lighting Panel" -- Any panel used in a light and power distribution system, having all (or the majority) of its branches single pole and rated the same.

"Lighting and Appliance Branch Circuitry" -- All or any portion of branch circuits outgoing from a lighting or appliance panel.

"Feeder" -- Any item of light and power circuitry used in a distribution system which is not lighting and appliance branch circuitry.

"Main Feeder" -- Any feeder which, at its supply end, is connected through its own overcurrent protection (and switching) device, and none other, directly to a main service or a main service overcurrent protection (and switching) device.

"Branch Feeder" -- A feeder, other than a main feeder, which complies with the definition of a branch circuit.

"Submain Feeder" -- Any feeder which is neither a main feeder nor a branch feeder.

"Distribution Panel" -- Any panel, used in a light and power distribution system, containing only multi-pole branches and with all (or the majority) of its branches used for feeders supplying other panels.

"Power Panel" -- Same as distribution panel, except with all (or the majority) of its branches used for feeders which do not supply other panels.

"Motor Power Circuit" -- Any circuit which operates nominally at 100 volts or more, and which carries electrical input energy to a motor.

"Motor Control Circuit" (used in conjunction with a motor for which a magnetic starter is supplied) -- Any circuit (other than a motor power circuit), which operates nominally at 100 volts or more, and which carries current intended for directing or indicating the performance of a motor starter.

"Motor Control Circuit" (used in conjunction with a motor for which a manual starter is supplied) -- Any circuit containing an extension of power circuit wires, other than those constituting the direct connection between source of supply, starter and motor.

"Motor Control Actuating Device" -- Any device which performs a switching function in a motor control circuit (pushbuttons, automatic contacting devices, etc.).

"Motor Control Actuated Device" -- Any device which functions in response to voltage received from a motor control circuit (pilot lights, solenoids, etc.)

"Package Unit" -- An item of equipment having one or more motors or other electric energy consuming elements integrally factory mounted on a single base, complete with all associated control devices and interconnecting wiring.

"Low Voltage" -- Below 50 volts.

"Process Control System" -- An overall control and/or logging system of a low voltage, electronic or pneumatic type available as a fully installed "package" from specialty manufacturers (commonly referred to as a "Temperature Control System" or an "Automatic Control System" or a "Building Management System" where used in conjunction with air conditioning).

"Grade Slab" -- A building floor slab which is in contact with or directly over grade (earth).

"Building Confines" -- The extent of a building, as defined by the outside surfaces of its peripheral walls, the top surface of its roof, and the underside surface of its grade slab.

"Distribution Switch" -- Any switch used in a light and power system other than a tumbler, toggle or specialty switch in the "wiring device" category.

"Normal Electric Work Conditions" -- Locations within building confines which are neither damp, wet nor hazardous and which are not used for air handling.

"Underground" -- Subsurface and exterior to building foundations.

"At Underside of Grade Slab" -- Under a grade slab and integrated into it.

"Below Grade Slab" -- Under a grade slab but not integrated into it.

"Standard" (as applied to wiring devices) -- Not of a separately designated individual type.

"Raceway" -- Any pipe, duct, extended enclosure, or conduit (as specified for a particular system) which is used to contain wires, and which is of such nature as to require that the wires be installed by a "pulling in" procedure.

"Specialty Cast-in-Floor Raceway" -- Underfloor duct, cellular deck and the like.

"Concealed" (as applied to circuitry) -- Covered completely by building materials, except for penetrations (by boxes and fittings) to a level flush with the surface as necessitated by functional or specified accessibility requirements.

"Exposed" (as applied to circuitry) -- Not covered in any way by building materials.

"Subject to Mechanical Damage" -- Exposed within seven feet of the floor in mechanical rooms, vehicular spaces, or other spaces where heavy items (over 100 pounds) are moved around or rigged as a common practice or as required for replacement purposes.

"Primary" (as applied to light and power distribution) -- Over 600 volts.

"Secondary" (as applied to light and power distribution) -- Under 600 volts.

"Assembly" -- A defined set of elements of electric work.

B. The following shall be treated as damp or wet locations within building confines, regardless of whether or not a high ambient moisture level is found to exist:-

1. Spaces where any designations indicating weatherproof (WP) or vapor-proof (VP) appear on the drawings.

2. Cooling tower areas.

3. Below waterproofing in slabs applied directly on grade.

4. Kitchens up to a height of 18" above finished floor.

5. Outside of waterproofing in foundation walls in contact with grade.

6. Above waterproofing in slabs having no building above.

7. Above waterproofing in fill on slabs having no building above.

8. Spaces containing equipment owned and/or maintained by the electric utility company.

C. Electric work in slabs, walls or suspended ceilings which bound on a space defined as a damp or wet location shall meet the damp or wet location requirements if it enters into, or opens into the damp or wet location in any way.

D. Where the word "conduit" is used without specific reference to type, it shall be understood to mean "raceway".

E. Except where modified by a specific notation to the contrary, it shall be understood

that the indication and/or description of any electrical item in the drawings and specifications for electrical work carries with it the instruction to furnish, install and connect the item as part of the electrical work regardless of whether or not this instruction is explicitly stated.

F. It shall be understood that the specifications and drawings are complementary and are to be taken together for a complete interpretation of the work. Where there are conflicts between the drawings and specifications or within the specifications or drawings themselves, the items of higher standard shall govern.

G. To the extent that they govern the basic work, the specifications also govern change order work if any.

H. No exclusion from or limitation in, the symbolism used on the drawings for electrical work or the language used in the specifications for electrical work shall be interpreted as a reason for omitting the appurtenances or accessories necessary to complete any required system or item of equipment.

I. The drawings for electrical work utilize symbols and schematic diagrams which have no dimensional significance. The work shall, therefore, be installed to fulfill the diagrammatic intent expressed on the electrical drawings, but in conformity with the dimensions indicated on the final working drawings, field layouts and shop drawings of all trades. In particular, information as to the exact size, location and electrical connection points for mechanical equipment shall be derived by reference to HVAC and Plumbing documents.

J. Certain details appear on the drawings for electrical work which are specific with regard to the dimensioning and positioning of the work. These are intended only for general information purposes. They do not obviate field coordination for individual items of the indicated work.

K. Information as to general construction and architectural general construction and architectural features and finishes shall be derived from structural and architectural drawings and specifications only.

L. The use of words in the singular shall not be considered as limiting where other indications denote that more than one item is referred to.

M. Ratings of devices, materials and equipment specified without reference to specific performance criteria shall be understood to be nominal or nameplate ratings established by means of industry standard procedures.

N. The restriction of conductors in wires to copper, as specified elsewhere, shall be understood to also apply to all conductors (wire, cable or bus as applicable), including those provided as part of factory assembled components such as transformers, switchboards, panelboards, panelettes, bus duct, switchgear, power

centers], overcurrent protection and switching devices. This restriction shall apply equally to all such equipment regardless of indications (or lack thereof) elsewhere to the contrary. Aluminum will not be acceptable.

PART 2 - PRODUCTS

2.1 TOUCH UP PAINT

A. For Equipment: Equipment manufacturer's paint selected to match installed equipment finish.

B. Galvanized Surfaces: Zinc-rich paint recommended by item manufacturer.

2.2 ACCESS DOORS IN FINISHED CONSTRUCTION

A. Access doors as required for operation and maintenance of concealed equipment, valves, controls, etc. will be coordinated by general contractor.

1. Access doors shall be of ample size, minimum of 16 inches x 16 inches (40 cm. x 40 cm.).

B. Furnish (confirm with GC) access doors as required for operation and maintenance of concealed equipment, valves, controls, etc., and coordinate their delivery with the installing Trade.

1. Coordinate and prepare a location, size, and function schedule of access required and deliver to a representative of the installing Trade.

2. Doors shall be minimum size 16 inches x 16 inches (40 cm. x 40 cm.) as manufactured by Karp Associates, Inland Steel Products "Milcor", “MIFAB” or other approved in accordance with the following schedule:

Location	Type	Catalog Number
Plaster Ceiling	Recessed Door Panel	Karp DSC-210-PL Milcor Style AP MIFAB-CAD-PL
Acoustic Tile Ceiling	Recessed Door Panel for Tile	Karp DSC-210 Milcor Style AT MIFAB-CAD
Plaster Wall	Flush Door Panel	Karp DSC-214-PL Milcor Style K MIFAB-CAD-PL-PL
Drywall	Flush Door Panel	Karp DSC-214-M Milcor Style DW MIFAB-MDW

Drywall	Recessed Door Panel	Karp-RDW-210 MIFAB-CAD-FL
Ceramic Tile Walls	Flush Door Panel	Karp DSC-214-M Milcor Style M MIFAB-UA
Masonry Wall	Flush Door Panel	Karp DSC-214-M Milcor Style M MIFAB-UA
3-Hour Rated Masonry Shaft	Flush Door Panel	Karp DSC-211-FRT MIFAB-MPFR-SD
1-1/2 Hour Rated Shaft	Flush Door Panel	Karp KRP-150-FR Milcor Fire Door Rated Access Door Panel MIFAB-MPFR

3. Doors and frames shall be given a factory prime coat of corrosion resistant paint.

4. Type shall be as approved by Architect.

5. Frames shall be welded minimum l4 gauge steel, mitered corners ground smooth with anchors.

6. Finish shall be as selected and approved by Architect.

7. Doors shall be minimum 14 gauge steel, heavy hinges flush with frame, invisible when closed.

PART 3 - EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

B. Refer to equipment specifications in Divisions 2 through 16 for rough-in requirements.

3.2 ELECTRICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:

1. Coordinate electrical systems, equipment, and materials installation with other building components.

2. Verify all dimensions by field measurements.

3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for electrical installations.

4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.

5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.

6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.

7. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

8. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.

9. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations.

10. Coordinate location of access panels or doors where outlet boxes, junction boxes, or equipment are concealed behind finished surfaces.

11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.

B. Coordinate electrical service connections to components furnished by utility companies.

1. Coordinate installation and connection of exterior underground and overhead utilities and services.
2. Comply with requirements of authorities having jurisdiction and of utility company providing electrical power and other services.

C. Locations of all devices, fixtures, and other visible components shall be as indicated on the architectural drawings. Mounting heights shall be as specified in Division 16 Section “Raceways and Boxes”.

D. Each piece of mechanical equipment located outside the building or on the roof shall be within 25 feet (7 m) of a duplex outlet. Where necessary to meet this criteria, provide duplex outlets in addition to those devices shown on the drawings. Each shall be complete with waterproof cover and integral GFI protection, and 20 ampere circuitry to the nearest 120 volt panel on the proper electric meter.

3.3 FIRESTOPPING

A. Apply firestopping to cable and raceway penetrations of fire-rated floor and wall assemblies to achieve fire-resistance rating of the assembly. Firestopping materials and installation requirements are specified in Division 7 Section "Firestopping."

3.4 FOUNDATIONS

A. General

1. All equipment, including but not limited to Switchgear, Switchboards, Motor control centers, Generators, Uninterruptible power supplies and battery racks, Automatic transfer switches, transformers shall be provided with foundations.

2. Furnish shop drawings showing adequate concrete reinforcing steel details and templates for all concrete foundations and supports, and all required anchor bolts and other appurtenances necessary for the proper installation of this equipment. All concrete work shall be shown in detail on the shop drawings, prepared by this trade.

3. Each piece of equipment shall be set on a concrete base minimum 4 inches (10 cm.) high and extending 3 inches (8 cm.) beyond the equipment in all directions. Bases shall be integrally keyed to structural slab.

3.5 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Section "Cutting and Patching." In addition to the requirements specified in Division 1, the following requirements apply:

1. Perform cutting, fitting, and patching of electrical equipment and materials required to:

(a) Uncover Work to provide for installation of ill-timed Work.

(b) Remove and replace defective Work.

(c) Remove and replace Work not conforming to requirements of the Contract Documents.

(d) Upon written instructions from the Architect, uncover and restore Work to provide for Architect observation of concealed Work.

2. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

3. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers.

B. Identify for future use with a tag at each unterminated end all low voltage (audio, data, Class 2, Class 3, PLTC, fire alarm, optical fiber, communications, coaxial, and network) cables.

3.6 REFINISHING AND TOUCH UP PAINTING

A. Clean damaged and disturbed areas and apply primer, intermediate, and finish coats to suit the degree of damage at each location.

B. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

C. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

D. Repair damage to PVC or paint finishes with matching touch up coating recommended by manufacturer.

3.7 FIELD QUALITY CONTROL

A. Inspect installed components for damage and faulty work, including the following:

1. Cutting and patching for electrical construction.

2. Touch up painting.

3.8 CLEANING AND PROTECTION

A. On completion of installation, including outlets, fittings, and devices, inspect exposed finish. Remove burrs, dirt, paint spots, and construction debris.

B. Protect equipment and installations and maintain conditions to ensure that coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

END OF SECTION 16050

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SECTION 16055 - OVERCURRENT PROTECTIVE DEVICE COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes computer-based, fault-current and overcurrent protective device coordination studies, and the setting of these devices. Protective devices shall be set based on results of the protective device coordination study.

1. Coordination of series-rated devices is permitted except where fully rated systems are required.

1.3 SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399.

C. Other Action Submittals:

1. Coordination-study input data, including completed computer program input data sheets.

2. Coordination-study report.

3. Equipment evaluation report.

4. Setting report.

5. Flash hazard analysis.

1.4 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Comply with IEEE 399 for general study procedures.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with NFPA 70 as amended by state and local codes.

E. Comply with NFPA 70E for flash hazard analysis.

PART 2 - PRODUCTS

2.1 COMPUTER SOFTWARE DEVELOPERS

A. Available Computer Software Developers: Subject to compliance with requirements, companies offering computer software programs that may be used in the Work include, but are not limited to, the following:

1. CYME International, Inc.

2. EDSA Micro Corporation.

3. Electrical Systems Analysis, Inc.

4. SKM Systems Analysis, Inc.

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399.

B. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399, Table 7-4.

C. Computer software program shall be capable of plotting and diagraming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.

B. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices not submitted for approval with coordination study may not be used in study.

3.2 FAULT-CURRENT STUDY

A. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project and use approved computer software program to calculate values.

B. Calculate momentary and interrupting duties on the basis of maximum available fault current.

C. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with the following:

1. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.50.

2. Low-Voltage Fuses: IEEE C37.46.

3. Circuit Breakers: IEEE C37.13.

D. Study Report: Enter calculated X/R ratios and interrupting (5-cycle) fault currents on electrical distribution system diagram of the report. List other output values from computer analysis, including momentary (1/2-cycle), interrupting (5-cycle), and 30-cycle fault-current values for 3-phase, 2-phase, and phase-to-ground faults.

E. Equipment Evaluation Report: Prepare a report on the adequacy of overcurrent protective devices by comparing fault-current ratings of these devices with calculated fault-current momentary and interrupting duties. Adjust device settings as required.

F. Flash Hazard Analysis: Determine the Flash Protection Boundary and the personal protective equipment that people within the Flash Protection Boundary shall use. Provide information required to properly label each piece of equipment to conform to the requirements of the applicable codes and standards.

3.3 COORDINATION STUDY

A. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 16 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.

2. Impedance of utility service entrance.

3. Electrical distribution system diagram showing the following:

   (a) Load current that is the basis for sizing continuous ratings of circuits for cables and equipment.

   (b) Circuit-breaker and fuse-current ratings and types.

   (c) Relays and associated power and current transformer ratings and ratios.

   (d) Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, and X/R ratios.

   (e) Generator kilovolt amperes, size, voltage, and source impedance.

   (f) Cables. Indicate conduit material, sizes of conductors, conductor material, conductor insulation, and length.

   (g) Busway ampacity and impedance.

   (h) Motor horsepower and code letter designation according to NEMA MG 1.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram:

   (a) Special load considerations, including starting inrush currents and frequent starting and stopping.

   (b) Magnetic inrush current overload capabilities of transformers.

   (c) Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.

   (d) Ratings, types, and settings of utility company's overcurrent protective devices.

   (e) Special overcurrent protective device settings or types stipulated by utility company.

   (f) Time-current-characteristic curves of devices indicated to be coordinated.

(g) Manufacturer, frame size, interrupting rating in amperes RMS symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.

(h) Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.

(i) Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes RMS symmetrical.

B. Perform coordination study and prepare a written report using the results of fault-current study and approved computer software program. Comply with IEEE 399.

C. Comply with NFPA 70, as amended by state and local codes for coordination of devices, and for overcurrent protection of circuit elements and devices.

1. Emergency Systems and Legally Required Standby Systems: Distribution system shall be selectively coordinated. Series rated devices shall not be used for distribution, regardless of any indication to the contrary.

D. Comply with IEEE recommendations for fault currents and time intervals.

E. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:

(a) Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.

(b) Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device shall protect transformer according to IEEE C57.12.00, for fault currents.

F. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Verify adequacy of phase conductors at maximum three-phase bolted fault currents, equipment grounding conductors, and grounding electrode conductors at maximum ground-fault currents.

G. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:

   (a) Device tag.
   (b) Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   (c) Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.
   (d) Fuse-current rating and type.
   (e) Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between series devices, including power utility company's upstream devices. Show the following specific information:

   (a) Device tag.
   (b) Voltage and current ratio for curves.
   (c) Three-phase and single-phase damage points for each transformer.
   (d) No damage, melting, and clearing curves for fuses.
   (e) Cable damage curves.
   (f) Transformer inrush points.
   (g) Maximum fault-current cutoff point.

3. Completed data sheets for setting of overcurrent protective devices.

3.4 OVERCURRENT PROTECTIVE DEVICE SETTING

A. Manufacturer's Field Service: Engage a factory-authorized service representative, of electrical distribution equipment being set and adjusted, to assist in setting of overcurrent protective devices within equipment.

B. Testing: Perform the following device setting and prepare reports:

1. After installing overcurrent protective devices and during energizing process of electrical distribution system, perform the following:

   (a) Verify that overcurrent protective devices meet parameters used in studies.
   (b) Adjust devices to values listed in study results.

2. Adjust devices according to recommendations in Chapter 7, "Inspection and Test Procedures," and Tables 10.7 and 10.8 in NETA ATS.

END OF SECTION 16055

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SECTION 16060 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

B. Related sections include the following:

1. Division 16 Section "Conductors and Cables."

2. Division 16 Section "Raceways and Boxes."

3. Division 16, Section "Underground Ducts and Utility Structures."

4. Division 16, Section "Lightning Protection."

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Ground rods.

B. Field Test Reports: Written reports specified in Part 3.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories, Inc.

B. Comply with UL 467.

C. Comply with NFPA 70, as amended by state and local codes.

D. Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system.

E. Comply with applicable BICSI standards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Erico Products, Inc.

2. Ideal Industries, Inc.

3. Kearney.

4. O-Z/Gedney Co.

5. Raco, Inc.

6. Thomas & Betts, Electrical

2.2 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 16 Section "Conductors and Cables."

B. Material: Copper

C. Equipment Grounding Conductors: Insulated with green-colored insulation.

D. Isolated Ground Conductors: Insulated with green-colored insulation with yellow stripe. On feeders with isolated ground, use colored tape - alternating bands of green and yellow tape to provide a minimum of three bands of green and two bands of yellow.

E. Grounding Electrode Conductors: Stranded cable.

F. Underground Conductors: Bare, tinned, stranded, unless otherwise indicated.

G. Bare Copper Conductors: Comply with the following:

1. Solid Conductors: ASTM B 3.

2. Assembly of Stranded Conductors: ASTM B 8.

3. Tinned Conductors: ASTM B 33.

H. Copper Bonding Conductors: As follows (except where otherwise indicated):

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 0.25-inch (6.4 mm) in diameter.

2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.

3. Bonding Jumper: Bare copper tape, braided bare copper No. 30 AWG

conductors, terminated with copper ferrules; 1.625 inch (42 mm) wide and 1/16 inch (1.5 mm) thick.

4. Tinned Bonding Jumper: Tinned-copper tape, braided copper No. 30 AWG conductors, terminated with copper ferrules; 1-5/8 inches (42 mm) wide and 1/16 inch (1.5 mm) thick.

I. Grounding Bus: Bare, annealed copper bars of rectangular cross section, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with mounting insulators.

2.3 CONNECTOR PRODUCTS

A. Comply with IEEE 837 and UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Connectors: Bolted-pressure-type connectors, or compression type.

C. Bolted Clamps: Heavy-duty type.

D. Pressure Connectors: High-conductivity-plated units.

E. Main Grounding System - Welded Connections: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions for the specific types, sizes, and combinations of conductors and other items to be connected.

1. Manufacturer: Erico “Cadweld” system.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel with high-strength steel core and electrolytic-grade copper outer sheath, molten welded to core.

1. Size: 3/4 inch by 10 feet (19 by 3000 mm).

PART 3 - EXECUTION

3.1 APPLICATION

A. Equipment Grounding Conductor Application: Comply with NFPA 70, as amended by state and local codes, for sizes and quantities of equipment grounding conductors except where specific types, larger sizes or more conductors are indicated.

1. Provide equipment grounding conductors with circuit conductors for all feeders and branch circuits.

B. Signal and Communications: For telephone, alarm, voice and data and other communication systems, provide a #4 AWG minimum green insulated copper conductor in raceway from the grounding electrode system to each service location, antenna, terminal cabinet, wiring closet and central equipment location.

C. The ground bus of switchboards and switchgear shall be connected to the main grounding electrode by means of insulated grounding electrode conductors run in intermediate metallic conduit and sized as per Code.

D. The neutral bar of each individually enclosed service switch shall be bonded to its enclosure on the line side of a removable link (included therein), and connected to the main grounding electrode by means of insulated grounding electrode conductors run in intermediate metallic conduit and sized as per Code.

E. The emergency generator system neutral shall be grounded by means of a connection from the [neutral bar in the generator main circuit breaker enclosure to the main grounding electrode by means of an insulated grounding electrode conductor run in intermediate conduit and sized as per Code. Include a bonding connection from the neutral to the equipment enclosure.

F. The Uninterruptible Power Source (UPS) system neutral shall be grounded by means of a connection from the neutral bar in the UPS main circuit breaker enclosure to the main grounding electrode by means of an insulated grounding electrode conductor run in intermediate conduit and sized as per Code. Include a bonding connection from the neutral to the equipment enclosure.

G. The main grounding electrode shall be an accessible point on the nearest metallic main water service pipe. Connection shall be made on the street side of the main valve utilizing a ground clamp of a type specifically manufactured for the purpose. Bonding jumpers shall be provided around the water meters (if provided) and around insulating joints and/or sections, utilizing conductors sized as per Code and run in IMC. Bond the structural steel to the grounding electrode system.

H. The water pipe ground shall be supplemented by an additional "made" electrode consisting of buried [ground rods] [copper plates laid on 3 inch (75 mm) charcoal bed], and provided in sufficient quantity so as to have a measured resistance to ground of not more than 5 ohms. Establish a bonding connection from the "made" electrode consisting of green insulated conductors run in IMC and sized as per Code.

I. Bond the reinforcing bars in concrete to the nearest grounding electrode. Where reinforcing bars are installed in building foundations and footings protect the bonding conductor during construction. Arrange for inspection by the authority having jurisdiction prior to placement of concrete.

J. The neutral of secondary winding of each low voltage (i.e., less than 600 volts) transformer shall be grounded to the grounding electrode as specified hereinafter by means of an insulated grounding conductor sized as per Code and run in IMC. The neutral of each transformer shall be bonded to the transformer enclosure by means of an insulated conductor sized as per code. If not factory installed the jumper shall be field installed within the transformer enclosure.

K. At each secondary voltage to secondary voltage transformer, bond the metallic water piping system to the transformer neutral at the nearest available location utilizing conductors sized equal to the grounding electrode conductor and run in conduit.

L. The grounding electrode for each low voltage (both windings 600 volts or less) transformer shall be the main water service pipe entering the building taken at a point on the street side of its main valve. Utilize a common ground clamp on the main water pipe, with means for connecting the multiple separate grounding conductors from the various transformers. In lieu of multiple separate grounding conductors, multiple connection to a "ground bus cable" may be utilized. The ground bus cable shall consist of a 500 MCM green coded insulated copper conductor run in 1-1/2 inch (DN 41) threaded steel conduit from the street side of the main water service valve, throughout the building to all dry type transformer locations requiring grounding. The ground bus cable shall be connected to the main water pipe by means of a ground clamp of a type specifically manufactured for the purpose. At each transformer location, establish a "grounding electrode" connection point by arranging a break in the "ground bus cable" conduit exposing the cable for not more than a twelve inch length. Ends of conduit at the break shall be equipped with bushings. The connection shall be made by means of an irreversible compression connector listed for the purpose or an exothermic weld.

M. Include a properly sized green insulated grounding conductor within the conduit for each feeder supplying a panel containing an isolated ground bus (i.e., insulated from ground). Increase indicated conduit size if necessary to accommodate this conductor. Connect to the neutral grounding facility for feeders originating at the service entry point or at 480-120/208 volt stepdown transformers as applicable.

N. Bond metallic conduits containing grounding electrode conductors and main bonding conductors to the ground bus service enclosure and/or grounding electrode at both ends of each run utilizing grounding bushings and jumpers. Bonding jumpers shall be sized equal to the grounding electrode conductors.

O. Provide grounding bonds for all metallic conduits of the light and power system which terminate at (or in pits below) distribution equipment for which a ground bus is specified. Accomplish this by equipping the conduits with bushings of the grounding type connected individually to the ground bus.

P. Provide supplementary ground bonding to maintain continuity of the equipment and raceway grounding system as follows:

1. Bonding jumpers shall be applied where wiring devices (receptacles and switches) are not equipped with approved self-grounding features. Include any necessary field modifications for termination of the bonding jumpers so as to insure grounding continuity.

2. Bonding jumpers shall be applied to insure that grounding continuity does not depend solely on the supporting screws fastening metallic enclosures together.

3. Include any necessary field modifications for termination of the bonding jumpers so as to insure grounding continuity.

Q. Provide grounding of raised metallic floors used to contain wiring to computers and/or other equipment. Where the floor system is of a type that is specifically designed by the manufacturer to maintain ground continuity through its metallic structural support system, the grounding may be accomplished by means of no fewer than (8) bonding connections spaced equally about the perimeter but in no

case more than 100 feet (30 m) apart. Utilize #8 AWG green insulated copper conductors for the connection of the bonding locations to the ground bus in the panel serving the equipment and the service ground point. If the raised floor is to be used as an air handling plenum, the insulation shall be of a fluoropolymer type suitable for use in plenums without raceway. If the floor system is not designed to maintain ground continuity through the metallic structural support system, alternating support pedestals in each direction must be connected to the bonding conductors.

R. Provide a ground connection for each 100 feet (30 m) of run of cable tray, and for each isolated run of less than 100 feet (30 m), by means of a #6 AWG green coded insulated copper conductor run in 3/4 inch (DN 21) conduit. The grounding electrode for each run of cable tray requiring same shall consist of a cadweld connection to adjacent structural steel at a point where only fireproofing and not structural concrete is applied to it or the nearest cold water pipe if steel is not available. Utilize ground clamps of a type specifically manufactured for the purpose.

S. Provide supplementary ground bonding for each motor control center (MCC) as follows:

1. Provide equipment grounding conductors as required to insure that all sections (including attached integral or field installed pullboxes) are bonded together by means of these conductors and by means of the MCC ground bus (if a ground bus is included in the MCC).

2. Provide grounding bushings and jumpers as required to insure that all conduits and any contained equipment grounding conductors are bonded to the enclosure grounding conductors (or ground bus).

T. Where specifically noted on the drawings, or described hereinbefore in this Section, include insulated equipment and raceway grounding conductors run within the raceways. Where insulated equipment grounding conductors required for feeders have not been included in the quantities of conductors indicated on the drawings, incorporate such conductors in accordance with the electrical code. Adjust conduit sizing if required.

U. Common Ground Bonding With Lightning Protection System: Bond electric power system ground directly to lightning protection system grounding conductor at closest point to electric service grounding electrode. Use bonding conductor sized same as system ground conductor and installed in conduit.

V. Grounding Underground Distribution System Components complies with IEEE C2 grounding requirements and the following. Provide additional grounding if required to comply with Utility Company standards.

1. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, non-shrink grout.

2. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.

3. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with pad mounted equipment by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.2 INSTALLATION

A. General: Ground electrical systems and equipment according to NFPA 70, as amended by state and local codes, except where Drawings or Specifications exceed such requirements.

B. Grounding Rods: Locate a minimum of 1-rod length from each other and at least the same distance from any other grounding electrode.

1. Drive until tops are 2 inches (50 mm) below finished floor or final grade, except as otherwise indicated.

2. Interconnect with grounding-electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make these connections without damaging copper coating or exposing steel.

C. Grounding Conductors: Route along the shortest and straightest paths possible, except as otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

D. Underground Grounding Conductors: Use bare copper wire. Bury at least 24 inches (600 mm) below grade.

E. Metal Water Service Pipe: Provide insulated copper grounding conductors, sized as indicated, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding-clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Provide a grounding jumper with the same size conductor across dielectric fittings. Bond grounding-conductor conduit to conductor at each end.

F. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with grounding-clamp connectors.

G. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps.

3.3 CONNECTIONS

A. General: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and to make contact points closer in order of galvanic series.

2. Make connections with clean, bare metal at points of contact.

3. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Use for connections to structural steel and for underground connections, except those at test wells. Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Equipment Grounding-Wire Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

D. Noncontact Metal Raceway Terminations: Where metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically noncontinuous conduits at both entrances and exits with grounding bushings and bare grounding conductors, except as otherwise indicated.

E. Tighten screws and bolts for grounding and bonding connectors and terminals according to manufacturer's published torque-tightening values. Where these requirements are not available, use those specified in UL 486A and UL 486B.

F. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by manufacturer of connectors. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

G. Moisture Protection: Where insulated grounding conductors are connected to grounding rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage an independent electrical testing organization to perform tests described below.

B. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal.. Measure ground resistance not less than 2 full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.

C. Maximum grounding resistance shall be less than or equal to 5 ohms.

D. Excessive Ground Resistance: Where resistance to ground exceeds specified values, provide additional grounding to achieve required results.

E. Report: Prepare test reports, certified by the testing organization, of ground resistance at each test location. Include observations of weather and other phenomena that may affect test results.

F. Field Test Reports: Submit written test reports to include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

END OF SECTION 16060

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SECTION 16075 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes electrical identification materials and devices required to comply with ANSI C2, NFPA 70 - as amended by state and local codes, OSHA standards, and the requirements of the authorities having jurisdiction.

1.3 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

B. Schedule of Nomenclature: An index of electrical equipment and system components used in identification signs and labels.

C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70, as amended by state and local codes.

B. Comply with ANSI A13.1 and NFPA 70 for color-coding.

C. Comply with ANSI Z535-2, Z535-4, and NFPA 70E.

D. Comply with ANSI C2.

E. Comply with 29 CFR 1910.145

1.5 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

C. Coordinate installation of identifying devices with location of access panels and doors.

D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY AND CABLE LABELS

A. Comply with ANSI A13.1, Table 3, for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.

1. Color: Black letters on orange field.

2. Legend: Indicates voltage and service.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

E. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.

B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

C. Aluminum Wraparound Marker Labels: Cut from 0.014-inch- (0.35-mm-) thick aluminum sheet, with stamped, or embossed legend, and fitted with tabs and matching slots for permanently securing around wire or cable jacket or around groups of conductors.

D. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch (50 by 50 by 1.3 mm), with stamped legend, punched for use with self-locking nylon tie fastener.

E. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and polyester or nylon tie for attachment to conductor or cable.

1. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.

2.3 UNDERGROUND-LINE WARNING TAPE

A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.

1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.

2. Compounded for permanent direct-burial service.

3. Embedded continuous metallic strip or core.

4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS, NAMEPLATES AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Engraved Plastic Warning Labels, Nameplates and Signs: Engraving stock, melamine plastic laminate, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.

1. Engraved legend with black letters on white face.
2. Punched or drilled for mechanical fasteners.

C. Baked-Enamel Warning Signs for Interior Use: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for the application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Exterior, Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 48 INCHES (1200 MM).". Adjust clearance dimensions as required for system voltage and equipment configuration.

3. Arc Flash Warning: “POTENTIAL ARC FLASH HAZARD - APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AND TOOLS REQUIRED WHEN WORKING ON THIS EQUIPMENT.”

F. Fasteners for Nameplates and Signs: Self-tapping, stainless-steel screws or No. 10/32, stainless-steel machine screws with nuts and flat and lock washers.

2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.

1. Minimum Width: 3/16 inch (5 mm).

2. Tensile Strength: 50 lb (22.3 kg) minimum.

3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).

4. Color: Black, except where used for color-coding.

B. Paint: Formulated for the type of surface and intended use.

1. Primer for Galvanized Metal: Single-component acrylic vehicle formulated for galvanized surfaces.

2. Primer for Concrete Masonry Units: Heavy-duty concrete masonry unit block filler.

3. Primer for Concrete: Exterior concrete and masonry primer.

4. Enamel: Exterior semigloss acrylic enamel.

PART 3 - EXECUTION

3.1 APPLICATION

A. Accessible Raceways and Cables of Auxiliary Systems: Identify the following systems with color-coded, self-adhesive vinyl tape applied in bands or with snap-around, color-coding bands:

1. Fire Alarm System: Red.

2. Telecommunication System: Green and yellow.

3. Control Wiring: Green and red.

B. Power-Circuit Conductor Identification: For primary and secondary conductors No. 1/0 AWG and larger in vaults, pull and junction boxes, manholes, and handholes use aluminum wraparound marker labels or non-ferrous metal tags. Identify source and circuit number of each set of conductors. For single conductor cables, identify phase in addition to the above.

C. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use aluminum wraparound marker labels. Identify each ungrounded conductor according to source and circuit number.

D. Ground fault interrupter outlets: Identify receptacles supplied by ground fault interrupter circuit breakers or by upstream ground fault interrupter receptacles. Use engraved letters on device plate.

E. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number.

F. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.

1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.

2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.

3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable. Install underground-line warning tape for both direct-buried cables and cables in raceway.

H. Warning Labels for Cabinets, Boxes, and Enclosures for Power and Lighting: Comply with 29 CFR 1910.145 and apply warning signs. Identify system voltage with black letters on an orange background. Apply to exterior of door, cover, or other access.

1. Equipment with Multiple Power or Control Sources: Apply to door or cover of equipment including, but not limited to, the following:

(a) Power transfer switches.
(b) Controls with external control power connections.

2. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.

3. Switchboards, Panelboards, Equipment Control Panels, Meter Socket Enclosures, and Motor Control Centers: Labeled to warn of potential electric arc flash hazards. The label shall be located so as to be clearly visible before examination, adjustment, servicing, or maintenance of the equipment.

I. Instruction Signs:

1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer or for load shedding.

J. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

(a) Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.

(b) Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to Be Labeled:

(a) Panelboards, electrical cabinets, and enclosures.

(b) Access doors and panels for concealed electrical items.

(c) Electrical switchgear and switchboards.

(d) Transformers.

(e) Emergency system boxes and enclosures.

(f) Motor-control centers.

(g) Disconnect switches.

(h) Enclosed circuit breakers.

(i) Motor starters.

(j) Push-button stations.

(k) Power transfer equipment.

(l) Contactors.

(m) Remote-controlled switches, dimmer modules, and control devices.

(n) Battery racks.

(o) Power-generating units.

(p) Voice and data cable terminal equipment.

(q) Master clock and program equipment.

(r) Intercommunication and call system stations.

(s) Television/audio components, racks, and controls.

(t) Fire-alarm control panel and annunciators.

(u) Monitoring and control equipment.

(v) Uninterruptible power supply equipment.

(w) Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Attach signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

E. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

F. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded service, feeder, and branch-circuit conductors.

1. Color shall be factory applied the entire length of conductors, except the following field-applied color-coding methods may be used instead of factory-coded wire for sizes larger than No. 10 AWG:

(a) Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch- (25-mm-) wide tape in colors specified. Locate tape bands to avoid obscuring cable identification markings.

(b) Colored cable ties applied in groups of three ties of specified color to each wire at each terminal or splice point starting 3 inches (76 mm) from the terminal and spaced 3 inches (76 mm) apart. Apply with a special tool or pliers, tighten to a snug fit, and cut off excess length. Locate bands to avoid obscuring cable identification markings.

2. Colors for 208/120-V Circuits:
   (a) Phase A: Black.
   (b) Phase B: Red.
   (c) Phase C: Blue.

3. Colors for 480/277-V Circuits:
   (a) Phase A: Brown.
   (b) Phase B: Orange.
   (c) Phase C: Yellow.

G. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.

H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

I. Painted Identification: Install painted identification according to manufacturer's written instructions and as follows:

1. Clean surfaces of dust, loose material, and oily films before painting.

2. Prime surfaces using type of primer specified for surface.

END OF SECTION 16075

NEW PASSENGER TERMINAL
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SECTION 16080 - ELECTRICAL TESTING

P ART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes general requirements for electrical field testing and inspecting. Detailed requirements are specified in each Section containing components that require testing. General requirements include the following:

1. Coordination requirements for testing and inspecting

2. Reporting requirements for testing and inspecting.

1.3 QUALITY ASSURANCE

A. As specified in each Section containing electrical testing requirements.

PART 2 - PRODUCTS

NOT USED

PART 3 - EXECUTION

3.1 GENERAL TESTS AND INSPECTIONS

A. Where no specific requirements are given, provide testing in accordance with the latest version of the InterNational Testing Association (NETA) Acceptance Testing Specification for Electric Power Distribution Equipment and Systems.

B. Where tests are specified to be performed by an independent testing agency, prepare systems, equipment, and components for tests and inspections, and perform preliminary tests to ensure that systems, equipment, and components are ready for independent agency testing. Include the following minimum preparations as appropriate:

1. Perform insulation-resistance tests.

2. Perform continuity tests.

3. Perform rotation test (for motors to be tested).

4. Provide a stable source of single-phase, 208/120-V electrical power for test instrumentation at each test location.

C. Test and Inspection Reports: In addition to requirements specified elsewhere, report the following:

1. Manufacturer's written testing and inspecting instructions.

2. Calibration and adjustment settings of adjustable and interchangeable devices involved in tests.

3. Tabulation of expected measurement results made before measurements.

4. Tabulation of "as-found" and "as-left" measurement and observation results.

3.2 COMMISSIONING

A. Provide manpower as required to assist the commissioning agent, as required in Division 1 Section “GENERAL COMMISSIONING REQUIREMENTS” and Division 1 Section “HVAC COMMISSIONING REQUIREMENTS”.

END OF SECTION 16080

NEW PASSENGER TERMINAL
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SECTION 16119 - UNDERGROUND DUCTS AND UTILITY STRUCTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes underground conduits and ducts, duct banks, pull boxes and handholes , manholes , and other underground utility structures .

1.3 SYSTEM DESCRIPTION

A. Underground Ducts: Plastic conduit encased in concrete.

B. Manholes: Cast-in-place concrete.

C. Manholes: Underground, precast concrete utility structures.

1.4 SUBMITTALS

A. Product Data: For metal accessories for manholes and handholes, conduit and duct, duct bank materials, and miscellaneous components.

B. Shop Drawings: Show details and design calculations for precast manholes and handholes, including reinforcing steel. Stamp drawings with seal of registered professional structural engineer.

C. Certificate for concrete and steel used in underground precast concrete utility structures, according to ASTM C 858.

D. Product Test Reports: Indicate compliance with ASTM C857 and ASTM C858

E. Record Documents: Show dimensioned locations of underground ducts, handholes, and manholes.

1.5 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are Underwriters Laboratories listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

B. Comply with NFPA 70, as amended by state and local codes.

C. Comply with ANSI C2.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete units at site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.7 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify Architect not less than 2 days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without Architect's written permission.

1.8 COORDINATION

A. Coordinate layout and installation of ducts, manholes, and handholes with final arrangement of other utilities as determined in the field.

B. Coordinate elevations of duct and duct-bank entrances into manholes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations as required to suit field conditions and to ensure duct runs drain to manholes and handholes, and as approved by Architect.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering the specified products that may be incorporated in the Work include, but are not limited to, the following:

1. Underground Precast Concrete Utility Structures:

(a) Precast Division; Carder Concrete Products.

(b) Christy Concrete Products, Inc.

(c) Elmhurst-Chicago Stone Co.

(d) Riverton Concrete Products.

(e) A. Rotondo & Sons, Inc.

(f) Rotondo/Penn-Cast, Inc.

(g) Smith-Midland Corp.

(h) Utility Vault Co.

(i) Wausau Concrete Co.

2. Frames and Covers:

(a) Campbell Foundry Co.

(b) East Jordan Iron Works, Inc.

(c) McKinley Iron Works, Inc.

(d) Neenah Foundry Co.

3. Nonmetallic Ducts:

(a) Arnco Corp.

(b) Breeze-Illinois, Inc.

(c) CANTEX, Inc

(d) Carlon; Lamson & Sessions Company.

(e) Pipe & Plastic Group; Certainteed Products Corp.

2.2 CONDUIT AND DUCT

A. Rigid Plastic Underground Conduit: UL 651A, Type EB PVC.

B. Rigid Plastic Conduit: NEMA TC 2, Schedule 40 or Schedule 80 PVC, rated for use with 90 deg C conductors under all installation conditions.

C. Rigid Steel Conduit: ANSI C80.1, galvanized.

D. Plastic-Coated Rigid Steel Conduit and Fittings: NEMA RN 1.

E. PVC Conduit Fittings: NEMA TC 3.

F. Manufactured Bends: Not less than 36-inch (900 mm.) radius.

2.3 PULL BOXES AND HANDHOLES

A. Cast Metal Boxes: Cast aluminum, sized as indicated, with outside flanges and recessed, gasketed cover for flush mounting. Nonskid finish on cover.

B. Cover Legend: High voltage, electric, signal or other as directed by the Architect.

2.4 UNDERGROUND PRECAST CONCRETE UTILITY STRUCTURES

A. Where field poured manholes or handholes have been indicated on the drawings, precast units of equivalent size may be substituted, subject to compliance with all requirements specified in this Section.

B. Precast Units: Interlocking, mating sections, complete with accessory items, hardware, and features as indicated. Include concrete knockout panels for conduit entrance and sleeve for ground rod.

C. Design structure according to ASTM C 858.

D. Structural Design Loading: ASTM C 857, Class A-16.

E. Fabricate according to ASTM C 858.

F. Joint Sealant: Continuous extrusion of asphaltic butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand the maximum hydrostatic pressures at the installation location with the ground water level at grade.

G. Source Quality Control: Inspect structures according to ASTM C 1037.

2.5 ACCESSORIES

A. Duct Supports: Rigid PVC spacers selected to provide minimum duct spacings and concrete cover depths indicated, while supporting ducts during concreting.

B. Frames and Covers: Cast iron with cast-in legend ELECTRIC or SIGNAL or other as directed. Machine cover-to-frame bearing surfaces.

C. Sump Frame and Grate: Comply with FS RR-F-621, Type VII for frame and Type I for cover.

D. Pulling Eyes in Walls: Eyebolt with reinforcing bar fastening insert. 2-inch (50 mm) diameter eye, 1-inch (25 mm) by 4-inch (100 mm) bolt. Working load embedded in 6-inch (150 mm), 4000 psi (27.6 MPa) concrete: 13,000 pounds (6,000 kg.) minimum tension.

E. Bolting Inserts for Cable Stanchions: Flared, threaded inserts of noncorrosive, chemical resistant, nonconductive thermoplastic material; 1/2-inch (12 mm) internal diameter by 2-3/4 inches (68 mm) deep, flared to 1-1/4 inch (30 mm) minimum at base. Tested ultimate pull-out strength: 12,000 pounds (5,500 kg.) minimum.

F. Expansion Anchors for Installation After Concrete is Cast: Zinc-plated carbon steel wedge type with stainless-steel expander clip 1/2-inch (12 mm) bolt size, 5,300-pound (2,400 kg.) rated pull-out strength, and 6,800-pound (3,100 kg) rated shear strength minimum.

G. Cable Stanchions: Hot-rolled, hot-dipped galvanized "T" section steel, 2-1/4-inch (56 mm) size, punched with 14 holes on 1-1/2-inch (35 mm) centers for cable arm attachment.

H. Cable Arms: 3/16-inch (5 mm) thick hot-rolled, hot-dipped galvanized sheet steel pressed to channel shape, approximately 12 inches (300 mm) wide by 14 inches (350 mm) long and arranged for secure mounting in horizontal position at any position on cable stanchions.

I. Cable Support Insulators: High glaze, wet-process porcelain arranged for mounting on cable arms.

J. Ground Rods: Solid copper clad steel, 3/4-inch (18 mm) diameter by 10-feet (3 m) length.

K. Ground Wire: Stranded bare copper, No. 6 AWG minimum.

L. Ladder: UL-listed, heavy-duty wood, specifically designed for electrical manhole use. Minimum length equal to the distance from the deepest manhole floor to grade plus 3 feet (1 m).

M. Duct Sealing Compound: Nonhardening, safe for human skin contact, not deleterious to cable insulation, workable at temperatures as low as 35 deg F (1 deg C), withstands temperature of 300 deg F (149 deg C) without slump, and adheres to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and the common metals.

2.6 CONSTRUCTION MATERIALS

A. Brick: Conform to ASTM C 55, concrete brick Type I, Grade N.

B. Mortar: Conform to ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L), where packaged mix complying with ASTM C 387, Type M may be used.

C. Concrete: Conform to Division 16 Section "Basic Electric Materials and Methods" for concrete and reinforcing.

1. Strength: 3,000 psi (20.7 MPa) minimum 28-day compressive strength.

2. Aggregate For Duct Encasement: 3/8-inch (10 mm) maximum size.

PART 3 - EXECUTION

3.1 APPLICATION

A. Underground Duct Banks: Concrete encased rigid plastic underground conduit, except as noted below.

B. Duct Banks Under Paved Areas open to regular vehicular traffic: Reinforced concrete encased rigid plastic underground conduit.

C. Duct Banks Passing Under Buildings: Concrete encased rigid steel conduit.

D. Single Tier Duct Banks: Direct buried Schedule 40 PVC rigid plastic conduit, except utilize plastic coated rigid steel conduits where under buildings.

E. Manholes (and Handholes): Cast-in-place concrete or underground precast concrete utility structures.

3.2 EXAMINATION

A. Examine site to receive ducts and manholes for compliance with installation tolerances and other conditions affecting performance of the underground ducts and manholes. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.3 EARTHWORK

A. Excavation and Backfill: Conform to Division 16, Section "Basic Electrical Materials and Methods."

B. Restore surface features at areas disturbed by excavation, and reestablish original grades except as otherwise indicated. Replace removed sod as soon as possible after backfilling is completed. Restore all areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, or mulching.

C. Restore disturbed paving. Refer to "Cutting and Patching" in Division 1.

3.4 CONDUIT AND DUCT INSTALLATION

A. Install nonmetallic conduit and duct as indicated according to manufacturer's written instructions.

B. Slope: Pitch ducts minimum of 4 inches per 100 feet (1:300) to drain toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between 2 manholes to drain in both directions.

C. Curves and Bends: Use manufactured elbows for stub-ups at equipment and at building entrances. Use manufactured long sweep bends with a minimum radius of 25 feet (7.5 m) both horizontally and vertically at other locations.

D. Make joints in ducts and fittings watertight according to manufacturer's instructions. Stagger couplings so those of adjacent ducts do not lie in the same plane.

E. Duct Entrances to Manholes and Handholes: Space end bells approximately 10 inches (250 mm) on center for 5-inch (125 mm) ducts and varied proportionately for other duct sizes. Change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line. Grout end bells into manhole walls from both sides to provide watertight entrances.

F. Building Entrances: Transition from underground duct to conduit 10 feet (3 m) minimum outside the building wall. Use fittings manufactured for the purpose. Follow appropriate installation instructions below.

1. Concrete-Encased Ducts: Install reinforcing in duct banks passing through disturbed earth near buildings and other excavations. Coordinate duct bank with structural design to support duct bank at wall without reducing structural or watertight integrity of building wall.

2. Direct-Buried, Nonencased Duct Entering Nonwaterproofed Walls: Install a Schedule 40 galvanized-steel pipe sleeve for each duct. Caulk space between conduit and sleeve with duct-sealing compound on both sides for moisture-tight seal.

3. Waterproofed Wall and Floor Entrances: Install a watertight entrance-sealing device with the sealing gland assembly on the inside. Anchor device into masonry construction with 1 or more integral flanges. Secure membrane waterproofing to the device to make permanently watertight.

G. Separation Between Direct-Buried, Nonencased Ducts: 3 inches (75 mm) minimum for like services, and 6 inches (150 mm) minimum between power and signal ducts.

H. Concrete-Encased Nonmetallic Ducts: Support on plastic separators coordinated with duct size and required duct spacing, and install according to the following:

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, and secure separators to the earth and to ducts to prevent floating during concreting. Do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.

2. Concreting: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not use power-driven agitating equipment unless specifically designed for duct bank application. Pour each run of envelope between manholes or other terminations in 1 continuous operation. When more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (18 mm) reinforcing rod dowels extending 18 inches (450 mm) into the concrete on both sides of joint near the corners of the envelope.

3. Reinforcing: Reinforce duct banks where they cross disturbed earth, where they cross over or under underground utilities or other obstructions and where indicated.

4. Forms: Use the walls of the trench to form the side walls of the duct bank where the soil is self-supporting and concrete envelope can be poured without soil inclusions, otherwise, use forms.

5. Minimum Clearances Between Ducts: 3 inches (75 mm) between ducts and exterior envelope wall, 2 inches (50 mm) between ducts for like services, and 4 inches (100 mm) between power and signal ducts.

6. Depth: Except as otherwise indicated, install top of duct bank at least 30 inches (750 mm) below finished grade. Increase cover where required by field conditions. Clearance may be reduced (to a minimum of 18" (450 mm)) where passing over other utilities or obstructions or where necessary to avoid low points. Reinforce the concrete where clearance is so reduced.

I. Stub-Ups: Use rigid steel conduit for stub-ups to equipment. For equipment mounted on outdoor concrete pads, extend steel conduit a minimum of 5 feet (1.5 m) from edge of pad. Install insulated grounding bushings on the terminations. Couple steel conduits to the ducts with adapters designed for the purpose and then encase coupling with 3 inches (75 mm) of concrete.

J. Sealing: Provide temporary closure at terminations of ducts that are wired under this Project. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least 15 psi (1.03 MPa) hydrostatic pressure.

K. Pulling Cord: Install 100-pound (45 kg) test nylon cord in ducts, including spares.

3.5 UNDERGROUND UTILITY STRUCTURE INSTALLATION

A. Elevation: Install manholes with roof top at least 15 inches (375 mm) below finished grade. Install handholes with depth as indicated. Where indicated, cast handhole cover frame directly into roof of handhole and set roof surface 1 inch (25 mm) above grade.

B. Access: Install cast-iron frame and cover. For manholes, use 30-inch (750 mm) cover except as indicated. Use 30-inch (750 mm) cover for handholes, except use 24-inch (600 mm) covers for 24-inch (600 mm) by 24-inch (600 mm) handholes. Install brick chimney to support frame and cover and to connect cover with roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney. Set frames in paved areas and traffic ways flush with finished grade. Set other frames 1 inch (25 mm) above finished grade.

C. Hardware: Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cable and conductors and as indicated.

D. Field-Installed Bolting Anchors: Do not drill deeper than 3-7/8 inches (96 mm) for anchor bolts installed in the field. Use a minimum of 2 anchors for each cable stanchion.

E. Grounding: Install ground rod through floor in each structure with top protruding 4 inches (100 mm) above floor. Seal the floor opening against water penetration with waterproof nonshrink grout. Ground exposed metal components and hardware with bare copper ground conductor. Train conductors neatly around corners. Install on walls and roof using cable clamps secured with expansion anchors.

F. Cast-In-Place Underground Structure Installation: Conform to applicable requirements of Division 16 Section "Basic Electric Materials and Methods."

1. Finish interior surfaces with a smooth troweled finish.

2. Windows for Future Duct Connections: Form and pour concrete knock-out panels 1-1/2 to 2 inches (37 to 50 mm) thick, arranged as indicated.

G. Precast Concrete Underground Structure Installation: Install as indicated, according to manufacturer's written instructions and ASTM C 891.

1. Install units plumb and level and with orientation and depth coordinated with arrangement of connecting ducts to minimize bends and deflections required for proper entrances.

2. Support units on a level bed of crushed stone or gravel, graded from the 1-inch (25 mm) sieve to the No. 4 sieve and compacted to same density as adjacent undisturbed earth.

3.6 EXCAVATION FOR UNDERGROUND CONDUIT BANKS

A. Slope sides of excavations to comply with local codes and ordinances. Shore and brace as required for stability of excavation.

B. Shoring and Bracing: Establish requirements for trench shoring and bracing to comply with local codes and authorities. Maintain shoring and bracing in excavations regardless of time period excavations will be open.

1. Remove shoring and bracing when no longer required. Where sheeting is allowed to remain, cut top of sheeting at an elevation of 30 inches (750 mm) below finished grade elevation.

C. Install sediment and erosion control measures in accordance with local codes and ordinances.

D. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.

1. Do not allow water to accumulate in excavations. Remove water to prevent softening of bearing materials. Provide and maintain dewatering system components necessary to convey water away from excavations.
2. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey surface water to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.

E. Material Storage: Stockpile satisfactory excavated materials where directed, until required for backfill or fill. Place, grade, and shape stockpiles for proper drainage.

1. Locate and retain soil materials away from edge of excavations. Do not store within drip-line of trees indicated to remain.

2. Remove and legally dispose of excess excavated materials and materials not acceptable for use as backfill or fill.

F. Excavation for Underground Vaults and Electrical Structures: Conform to elevations and dimensions shown within a tolerance of plus or minus 0.25 foot (75 mm); plus a sufficient distance to permit placing and removal of concrete form work, installation of services, other construction, and for inspection.

1. Excavate, by hand, areas within drip-line of large trees. Protect the root system from damage and dry-out. Maintain moist conditions for root system and cover exposed roots with burlap. Paint root cuts of 1 inch (25 mm) in diameter and larger with emulsified asphalt tree paint.

2. Take care not to disturb bottom of excavation. Excavate by hand to final grade just before concrete reinforcement is placed.

G. Trenching: Excavate trenches for electrical installations as follows:

1. Excavate trenches to the uniform width, sufficiently wide to provide ample working room and a minimum of 6 to 9 inches (150 to 225 mm) clearance on both sides of raceways and equipment.

2. Excavate trenches to depth required to accommodate the installation of conduit (duct banks) in compliance with the requirements of Section 16119.

3. Limit the length of open trench to that in which installations can be made and the trench backfilled within the same day.

4. Where rock is encountered, carry excavation below required elevation and backfill with a layer of crushed stone or gravel prior to installation of raceways and equipment. Provide a minimum of 6 inches (150 mm) of stone or gravel cushion between rock bearing surface and electrical installations.

H. Cold Weather Protection: Protect excavation bottoms against freezing when atmospheric temperature is less than 35 deg F (1 deg 2 C).

I. Backfilling and Filling: Place soil materials in layers to required subgrade elevations for each area classification listed below, using materials specified in Part 2 of this Section.

1. Under walks and pavements, use a combination of subbase materials and excavated or borrowed materials.

2. Under building slabs, use drainage fill materials.

3. Under piping and equipment, use subbase materials where required over rock bearing surface and for correction of unauthorized excavation.

4. For raceways less than 30 inches (750 mm) below surface of roadways, provide 4-inch (100mm)thick concrete base slab support. After installation of raceways, provide a 4-inch (100mm)thick concrete encasement (sides and top) prior to backfilling and placement of roadway subbase.

5. Other areas, use excavated or borrowed materials.

J. Backfill excavations as promptly as work permits, but not until completion of the following:

1. Inspection, testing, approval, and locations of underground utilities have been recorded.

2. Removal of concrete formwork.

3. Removal of shoring and bracing, and backfilling of voids.

4. Removal of trash and debris.

K. Placement and Compaction: Place backfill and fill materials in layers of not more than 8 inches (200 mm) in loose depth for material compacted by heavy equipment, and not more than 4 inches (100 mm) in loose depth for material compacted by hand-operated tampers.

L. Before compaction, moisten or aerate each layer as necessary to provide optimum moisture content. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification specified below. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

M. Place backfill and fill materials evenly adjacent to structures, piping, and equipment to required elevations. Prevent displacement of raceways and equipment by carrying material uniformly around them to approximately same elevation in each lift.

N. Compaction: Control soil compaction during construction, providing minimum percentage of density specified for each area classification indicated below.

1. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum density for soils which exhibit a well-defined moisture-density relationship (cohesive soils), determined in accordance with ASTM D 1557 and not less than the following percentages of relative density, determined in accordance with ASTM D 2049, for soils which will not exhibit a well-defined moisture-density relationship (cohesionless soils).

(a) Areas Under Structures, Building Slabs and Steps, Pavements: Compact top 12 inches (300 mm) of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.

(b) Areas Under Walkways: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum density for cohesive material, or 95 percent relative density for cohesionless material.

(c) Other Areas: Compact top 6 inches (150 mm) of subgrade and each layer of backfill or fill material to 85 percent maximum density for cohesive soils, and 90 percent relative density for cohesionless soils.

2. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water. Apply water in minimum quantity necessary to achieve required moisture content and to prevent water appearing on surface during, or subsequent to, compaction operations.

O. Subsidence: Where subsidence occurs at electrical installation excavations during the period 12 months after Substantial Completion, remove surface treatment (i.e., pavement, lawn, or other finish), add backfill material, compact to specified conditions, and replace surface treatment. Restore appearance, quality, and condition of surface or finish to match adjacent areas.

3.7 CONCRETE ENCASEMENT FOR UNDERGROUND CONDUIT BANKS

A. Utilize the sides of the trench in formwork for underground conduit banks to the maximum extent possible. Utilize a splashboard to divert the concrete flow away from the trench sides to avoid dislodging soil and stones.

B. Provide reinforcement where required. Verify that any required reinforcement is installed prior to commencing placement of concrete.

C. Place concrete in accordance with the following:

1. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete," and as specified.

2. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location.

3. Cold-Weather Placement: Comply with provisions of ACI 306 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions or low temperatures.

4. When air temperature has fallen to or is expected to fall below 40°F (4°C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50°F (10°C) and not more than 80°F (27°C) at point of placement.

(a) Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.

(b) Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise accepted in mix designs.

D. Installation of Fire-Stopping Sealant: Install sealant, including forming, packing, and other accessory materials, to fill openings around electrical services penetrating floors and walls, to provide fire-stops with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs. Comply with installation requirements established by testing and inspecting agency.

3.8 FIELD QUALITY CONTROL

A. Testing: Demonstrate capability and compliance with requirements upon completion of installation of underground duct and utility structures.

1. Grounding: Test manhole grounding to ensure electrical continuity of bonding and grounding connections. Measure ground resistance at each ground rod and report results. Use an instrument specifically designed for ground-resistance measurements.

2. Duct Integrity: Rod ducts with a mandrel 1/4 inch (6 mm) smaller in diameter than internal diameter of ducts. Where rodding indicates obstructions in ducts, remove the obstructions and retest.

3. Water Tightness: Make internal inspection of manholes 3 months after completion of construction for indications of water ingress. Where leakage is noted, remove water and seal leak sources. Reinspect after 2 months and reseal remaining leak sources. Repeat process at 2 month intervals until leaks are corrected.

B. Inspect installed components for damage and faulty work, including the following:

1. Concrete for underground conduit runs.
2. Excavation for underground conduit runs.

C. Correct installations where possible, and retest to demonstrate compliance. Otherwise, remove and replace defective products and retest.

3.9 CLEANING

A. Pull brush through full length of ducts. Use round bristle brush with a diameter 1/2 inch (12 mm) greater than internal diameter of duct.

B. Clean internal surfaces of manholes including sump. Remove foreign material.

END OF SECTION 16119

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 16120 - CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes building wires and cables and associated splices, connectors, and terminations for wiring systems rated 600 volts and less.

1.3 SUBMITTALS

A. Product Data: for each type of product indicated.

B. Field Quality Control Test Reports.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide products specified in this Section that are Underwriters Laboratories listed and labeled.

1. The Terms "Listed and Labeled": As defined in the "National Electrical Code," Article 100.

B. Comply with NFPA 70, as amended by state and local codes.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.2 CONDUCTORS AND CABLES

A. Available Manufacturers:

1. American Insulated Wire Corp.; a Leviton Company.

2. General Cable Corporation.

3. Senator Wire & Cable Company.

4. Southwire Company.

5. Belden, Division Cooper Industries.

6. Cable & Wire Division, AT&T.

7. Pyrotenax.

B. Refer to Part 3 "Conductor and Insulation Applications" Article for insulation type, cable construction, and ratings.

1. Conductor Material: Copper, complying with NEMA WC 5 or 7; solid conductor for No. 10 AWG and smaller, stranded for No. 8 AWG and larger.

2. Conductor Insulation Types: Type THHN, THWN, XHHW complying with NEMA WC 5 or 7.

C. Electrical Circuit Protective System Cable: Where required by code, or where indicated on the drawings, feeders and circuitry are a fire rated cable system, except where enclosed within equivalent fire rated construction indicated on the architectural drawings. Mineral-insulated, metal-sheathed cable, Type MI.

2.3 CONNECTORS AND SPLICES

A. Available Manufacturers:

1. AFC Cable Systems, Inc.

2. AMP Incorporated/Tyco International.

3. Hubbell/Anderson.

4. O-Z/Gedney; EGS Electrical Group LLC.

5. 3M Company; Electrical Products Division.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

PART 3 - EXECUTION

3.1 WIRE AND INSULATION APPLICATIONS

A. Utilize copper conductors with THWN, THHN or XHHW insulation, except provide THHW-2, THWN-2 or XHHW-2 insulation for conductors 1/0 and larger in "wet" locations. Conductors utilized in underground installations are UL Listed for use in wet locations. Conductors are run in raceways as described in Section 16 “Raceways and Boxes”. Type THHW and THHW-2 are not utilized where excluded by conduit sizing. Type THWN are not utilized for connection to 100 percent rated overcurrent devices.

B. Electrical circuit protective system cable is utilized for feeders and circuitry which is required to be fire rated and which is not enclosed within equivalent fire rated construction indicated on the architectural drawings.

1. A one-hour rating is required for:

(a) Feeders for Emergency Systems except where run within space directly protected by sprinklers.

(b) Normal and emergency feeders to fire pump.

C. In general, cable ampacities are based on a 60 degree C rating for cables #1 AWG and smaller and on a 75 degree C rating for larger cables. In conjunction with this, note the following:

1. 75 degree C ratings may be utilized for cables #1 AWG and smaller where overcurrent protection and switching devices (OCD's), wiring devices and solidly connected equipment connected to such cables are listed and identified for use with 75 degree C rated conductors. (Note that these specifications require all OCD's - regardless of ampere rating to be suitable for use with 75 degree C rated conductors).

2. Increase indicated cable (and raceway) sizing as required for circuitry where conductors #1 AWG and smaller will connect directly to solidly connected utilization equipment whose load current will exceed the 60 degree C rating of the cable, and for which manufacturer's approval for cable terminations is less than 75 degrees C, or to receptacles whose ampere rating exceeds the 60 degree C rating of the connected cables unless such receptacles are listed for use with 75 degree C rated conductors. Note that accessible intermediate tap boxes may be utilized adjacent to 60 degree C rated terminations to allow conductor "upsizing" locally so as to comply with such termination requirements.

D. For low voltage systems where circuits are power limited in accordance with Class 2 or Class 3 requirements (as defined in Article 725 of the National Electrical Code) utilize cables having characteristics as follows:

1. Cables are of a fluoropolymer type having adequate fire-resistant and low-smoke producing characteristics and are U.L. listed for plenum use (Type CL2P for Class 2 circuits, type CL3P or CMP for Class 3 circuits), except that where run in conduit, they may be U.L. type CL3, or where run in cable trays they are U.L. type CMP.

E. For low voltage systems whose circuits are not power limited Class 2 or Class 3 (in accordance with the requirements of Article 725 of the National Electrical Code), and which are not telecommunications circuitry (in accordance with Article 800 thereof), utilize copper conductors having TFN insulation for sizes #16 AWG and smaller, and type THHN or THWN for sizes #14 AWG and larger. Wires are run in electric metallic tubing.

F. Low voltage circuits intended for the distribution of voice or data utilize communications cables (complying with requirements of Article 800 of the National Electrical Code) having characteristics as follows:

1. Cables are of a fluoropolymer type having adequate fire-resistant and low-smoke producing characteristics and are U.L. listed for plenum use (Type CMP), except that where run in conduit, they may be U.L. type CM.

2. Refer to Division 16, Section "Fire Protective Alarm System" for fire alarm system wiring.

3.2 INSTALLATION

A. Conceal cables in finished walls, ceilings and floors unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables, parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.

E. Support cables according to Division 16 Section "Basic Electrical Materials and Methods."

F. Seal around cables penetrating fire-rated elements according to Division 7 Section “Through-Penetration Firestop Systems."

G. Identify wires and cables according to Division 16 Section "Electrical Identification" and Division 16 Section “Supporting Devices”.

3.3 CONNECTIONS:

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Maintain all splices and joints in removable cover boxes or cabinets where they may be easily inspected.

D. Locate each completed conductor splice or joint in the outlet box, junction box, or pull box containing it, so that it is accessible from the removal cover side of the box.

E. Join solid conductors #8 AWG and smaller by securely twisting them together and soldering, or by using insulated coiled steel spring "wire nut" type connectors. Exclude "wire nuts" employing non-expandable springs. Terminate conductors #8 AWG and smaller by means of a neat and fast holding application of the conductors directly to the binding screws or terminals of the equipment or devices to be connected. Terminals and connectors are U.L. approved specifically for the application.

F. Join, tap and terminate stranded conductors #6 AWG and larger by means of solder sleeves, taps and lugs with applied solder or by means of pressure indent type connectors, or mechanical connectors utilizing ball tipped set screws. Apply pressure indent type connectors, utilizing tools manufactured specifically for the purpose and having features preventing their release until the full pressure has been exerted on the lug or connector. Factory installed equipment or device terminals are of types UL approved specifically for the application.

G. Except where wire nuts are used, build up insulation over conductor joints to a value

equal both in thickness and dielectric strength to that of the factory applied conductor insulation. Insulation of conductor taps and joints are by means of half-lapped layers of rubber tape, with an outer layer of friction tape; by means of half-lapped layers of approved plastic electric insulating tape; or by means of split insulating casings manufactured specifically to insulate the particular connector and conductor, and fastened with stainless steel or non-metallic snaps or clips.

H. Exclude splicing procedures for neutral conductors in lighting and appliance branch circuitry which utilize device terminals as the splicing points.

I. Exclude joints or terminations utilizing solder in any conductors used for grounding or bonding purposes.

J. Exclude all but solder or pressure indent type joints in conductors used for signaling or communications purposes.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 7 Section "Through-Penetration Firestop Systems."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both wall surfaces.

F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 7 Section "Joint Sealants."

J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 7 Section "Through-Penetration Firestop Systems."

K. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

L. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and

mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

M. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIREPROOFING WIRES AND CABLES:

A. Beyond the termination of raceways, apply fireproofing over the unprotected insulation and/or splices of the following:-

1. All service feeder cables ahead of main service overcurrent protection devices within all the pits, cable chambers or pull boxes they pass through and elsewhere where they are not enclosed in raceways.

2. Fire pump feeder cables wherever they extend beyond the termination of raceways.

3. All feeder wires and cables emanating from different secondary service connections or both normal and emergency supplies which, due to indications on the drawings or unavoidable field conditions are forced to enter the same unbarriered compartment of a cable chamber, cable pit, pull box or junction box.

B. Fireproofing of wires and cables is by means of a half-lapped layer of Scotch 77 fire and arc-proofing tape. The wrapped tape is secured by a band consisting of two layers of glass cloth electrical tape. Fireproofing is extended up into raceways. Fireproofing is applied in an overall manner to raceway groupings of conductors.

3.7 INSTALLATION OF CIRCUITRY FOR MISCELLANEOUS LOW VOLTAGE SYSTEMS:

A. Comply with requirements described in applicable subsections of this Section. In particular, note the following circuitry requirements for low voltage systems:

1. Wiring for miscellaneous low voltage systems may be run without conduit - subject to the approval of the local authorities - except where prohibited by other sections of these specifications or by indications on the drawings.

2. Where conduit is required, it is steel electric metallic tubing (EMT), except that it is galvanized intermediate steel conduit where located within 8 feet (2.4 m) of the floor in mechanical spaces (or is otherwise exposed to mechanical damage), or is intended for embedment in concrete.

3. Wires and cables have characteristics - in compliance with Articles 725 and/or 800 (as applicable) of the National Electrical Code - as described elsewhere in the specifications or drawings for this project, and are U.L. listed in accordance therewith.

4. Where wires and cables are permitted to be run without conduit, they are independently supported from the building structure or ceiling suspension systems at intervals not exceeding four feet on center, utilizing cable supports specifically approved for the purpose. Wires and cables do not rest on or depend on support from suspended ceiling media (tiles, lath, plaster, as well as splines, runners or bars in the plane of the ceiling), nor are they supported from pipes, ducts or conduits. Where cables are bundled together, separate bundles are provided separately for each type of cabling and separately for each independent system. Bundling and/or supporting ties are of a type suitable for use in a ceiling air handling plenum regardless of whether or not installed in a plenum.

5. Cables are tagged or labeled at each termination point and in each intermediate junction box, pull box or cabinet through which they pass.

6. Comply with applicable requirements for locating and routing circuitry, for installing circuitry, and for fire-stopping as described in other sub-section of this Section.

3.8 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing conductors and cables and before electrical circuitry has been energized, test for compliance with requirements.

2. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.3.1. Certify compliance with test parameters.

B. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 2 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

END OF SECTION 16120

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related sections include the following:

1. Division 16 Section “Underground Ducts and Utility Structures” for exterior ductbanks, manholes, and underground utility construction.

2. Division 16 Section “Basic Electrical Materials and Methods” for firestopping.

3. Division 16 Section “Supporting Devices” for raceway and box supports.

4. Division 16 Section “Wiring Devices” for devices installed in boxes and for floor-box service fittings.

1.3 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical non-metallic tubing.

C. FMC: Flexible metal conduit.

D. IMC: Intermediate metal conduit.

E. LFMC: Liquidtight flexible metallic conduit.

F. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70, as amended by state and local codes.

1.6 COORDINATION

A. Coordinate layout and installation of raceways, boxes, enclosures, cabinets and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. In other Part 2 articles where subparagraph titles below introduce lists, the following requirements apply for product selection.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering Products that may be incorporated in the Work include, but are not limited to, the following:

2.2 METAL CONDUIT AND TUBING:

A. Available Manufacturers

1. Alflex Corp

2. Grinnell Co./Tyco International; Allied Tube and Conduit Div.

3. LTV Steel Tubular Products Company.

4. Wheatland Tube Co.

5. Triangle PWC, Inc.

B. Rigid Steel Conduit: ANSI C80.1

C. IMC: ANSI C80.6.

D. PVC-Coated Steel Conduit: PVC-coated IMC.

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

E. EMT and Fittings: ANSI C80.3.

1. Fittings: Set-screw or compression.

F. FMC: Zinc coated steel.

G. LFMC: Flexible steel conduit with PVC jacket.

H. Fittings: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

(a) Fittings for EMT: Die-cast compression type.

(b) Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

I. RNC: NEMA TC 2, Schedule 40 and Schedule 80 PVC.

2.3 METAL WIREWAYS

A. Available Manufacturers:

1. Hoffman.

2. Square D

3. The Wiremold Company

B. Material and Construction: Sheet metal sized and shaped as indicated.

1. Dry locations: NEMA 250, Type1.

2. Damp or Wet locations: NEMA 250, Type 3R.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for a complete system.

D. Select features, unless otherwise indicated, as required to complete wiring system and to comply with NFPA 70.

E. Wireway Covers: Screw-cover type.

F. Finish: Manufacturer’s standard enamel finish.

2.4 SURFACE RACEWAYS

A. Surface Metal Raceway: Galvanized steel with snap-on covers. Finish with manufacturer’s standard prime coating and paint finish as selected by the architect.

1. Available Manufacturers:

(a) Thomas & Betts Corporation.

(b) Walker Systems, Inc; Wiremold Company (The)

(c) The Wiremold Co., Electrical Sales Division.

B. Types, sizes and channels as indicated and required for each application, with fittings that match and mate with raceways.

2.5 BOXES, ENCLOSURES AND CABINETS

A. Available Manufacturers:

1. Cooper Crouse-Hinds; Div. Of Cooper Industries, Inc.

2. Emerson/General Signal; Appleton Electric Company.

3. Erickson Electrical Equipment Co.

4. Hoffman.

5. Hubbell, Inc.; Killark Electric Manufacturing Co.

6. O-Z/Gedney; Unit of General Signal.

7. RACO; Division of Hubbell, Inc.

8. Spring City Electrical Manufacturing Co.

9. Thomas & Betts Corporation.

10. Walker Systems Inc.; Wiremold Company (The).

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast Metal Outlet and Device Bopxes: NEMA FB 1, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Floor Boxes: Cast metal, fully adjustable, rectangular.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast Metal Pull and Junction Boxes: NEMA FP 1 cast aluminum with gasketed cover.

H. Cabinets: NEMA 250, Type 1, galvanized steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel. Hinged door in front cover with flush latch and associated hinge. Key latch to match panelboards. Include metal barriers to separate wiring of different systems and voltage and include accessory feet where required for freestanding equipment.

I. Pull boxes for Telephone and Signal System Raceways: ANSI/EIA/TIA-569A

2.6 FACTORY FINISHES

A. Finish: For raceway, enclosure, or cabinet components, provide manufacturer's standard prime-coat finish ready for field painting.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Use the following wiring methods, except as specifically noted otherwise.

1. Exposed: Rigid steel or IMC.

2. Concealed: Rigid steel or IMC.

3. Underground, Single Run: RNC.

4. Underground, Grouped: RNC.

5. Connection to Vibrating Equipment (including transformers and hydraulic, pneumatic, electric solenoid, or motor driven equipment): LFMC.

6. Exposed within 30 feet (10 meters) chiller: PVC coated steel conduit.

7. Boxes and Enclosures: NEMA 250, Type 3R or 4.

B. Indoors: Use the following wiring methods:

1. IMC for all purposes and in all applications except where specifically excluded, or where alternate methods are specified below.

2. Normal and emergency feeders to fire pumps: Rigid steel conduit. Feeder conduit encased in 2 inches (5cm) of concrete (or other code approved equivalent) where conduits are not physically routed outside the building. Exclude concrete for jockey pumps and/or auxiliary pumps.

3. Control circuitry to fire pumps: Rigid steel conduit.

4. Utilize EMT for:

(a) Main and submain feeders.

(b) Branch feeders.

(c) Lighting and appliance branch circuitry.

5. Exposed lighting and appliance branch circuitry runs in finished spaces : Surface metal raceway.

6. Refer to appropriate Sections of Division 16 for additional requirements relating to wiring methods for control/signal transmission, fire alarm systems, telecommunications, and other communication and alarm system distribution.

7. Wiring methods listed above shall be restricted as follows:

   (a) Exclude EMT from concrete embedment, from locations where subject to mechanical damage and from exposed locations in finished spaces.

   (b) Exclude surface metal raceway from concealed installations, from locations where subject to mechanical damage and from wet or damp locations.

   (c) Utilize only intermediate or rigid steel conduit from runs in (or opening into) hazardous areas. Comply with electric code requirements regarding sealing fittings, boxes, enclosures as appropriate for the conditions of atmospheric contamination.

8. The following shall be treated as damp or wet locations within building confines, regardless of whether or not a high ambient moisture level is found to exist:

   (a) Spaces where any designations indicating weatherproof (WP) or vaporproof (VP) appear on the drawings.

   (b) Parking garage areas.

   (c) Loading docks.

   (d) Chiller areas.

   (e) Below waterproofing in slabs applied directly on grade.

   (f) Kitchens up to a height of 18inches (45 cm) above finished floor.

   (g) Outside of waterproofing in foundation walls in contact with grade.

   (h) Above waterproofing in slabs having no building above.

   (i) Above waterproofing in fill on slabs having no building above.

   (j) Spaces containing equipment owned and/or maintained by the electric utility company.

   (k) Electric work in slabs, walls or suspended ceilings which bound on a space defined as a damp or wet location shall meet the damp or wet location requirements if it enters into, or opens into the damp or wet location in any way.

   (l) Tug ramps, tug tunnels and other similar areas.

9. The following shall be interpreted as being "hazardous" locations regardless of actual condition of atmospheric contamination.

   (a) The entire floor to ceiling volume of space where any designations

indicating "explosion proof" (EP) are shown.

(b) Gas meter rooms.

(c) The volume included between the floor and a height of 18inches (45 cm) above the floor throughout all space designated for parking, including all associated above grade vehicular ramps and access ways, and all spaces on the floor not separated from the parking space by partitions.

(d) The entire floor to ceiling volume of all spaces designated for the storage of flammable anesthetics.

(e) The volume included between the floor and a height of 60 inches (150 cm) above the floor throughout all spaces designated for the administration of flammable anesthetics.

(f) The entire interior volume of any paint spray booth and its associated ductwork.

(g) The entire volume of any space falling within 20 feet (6 meters) of the open face of any paint spray booth, and which is not cut off by air tight, unpierced walls, partitions, slabs or other general construction elements.

(h) The entire floor to ceiling volume of any space designated for painting by means of open spraying or tank dipping.

(i) Electric work located in slabs, walls or suspended ceilings which bound on a space defined as a hazardous location shall meet the hazardous location requirements if it enters into, or opens into, the hazardous location in any way.

C. Minimum Raceway Size: 3/4 inch (DN 21) trade size.

D. Indicated Raceway Size: Raceway sizes indicated are based on non-flexible conduit. Where flexible type raceways are specified, increase raceway size as required to maintain code mandated maximum conduit fill.

E. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

2. EMT: Where embedded in concrete, utilize concrete compression type couplings, connectors and fittings of a type which assures ground continuity.

3. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

3.2 INSTALLATION

A. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot water pipes. Install horizontal raceway runs above water and steam piping.

B. Complete raceway installation before starting conductor installation.

C. Support raceway as specified in Division 16 Section "Supporting Devices."

D. Install temporary closures to prevent foreign matter from entering raceway.

E. Protect stub-ups from damage where conduits rise through floor slabs. Arrange so curved portion of bends is not visible above the finished slab.

F. Make bends and offsets so the inside diameter is not reduced. Unless otherwise indicated, keep the legs of a bend in the same plane and the straight legs of offsets parallel.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

1. Install concealed raceways with a minimum of bends in the shortest practical distance, considering type of building construction and obstructions, unless otherwise indicated.

H. Install exposed raceways parallel to or at right angles to nearby surfaces or structural members, and follow the surface contours as much possible.

1. Run parallel or banked raceways together on common supports.

2. Make parallel bends in parallel or banked runs. Use factory elbows only where elbows can be installed parallel; otherwise, provide field bends for parallel raceways.

I. Join raceways with fittings designed and approved for the purpose and make joints tight.

1. Use insulating bushings to protect conductors.

J. Tighten set screws of threadless fittings with suitable tool.

K. Equip all raceways, including those embedded in concrete which cross building expansion or control joints, with expansion fittings having flexible grounding bonds bypassing sliding parts. Arrange expansion fittings on concrete embedded raceways so that sliding action is not impeded.

L. Terminations:

1. Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely, and install the locknuts with dished part against the box. Use two locknuts, one inside and one outside box.

2. Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder. Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.

M. Install pull wires in empty raceways. Use No. 14 AWG zinc-coated steel or monofilament plastic line having not less than 200-lb (90 kg) tensile strength. Leave not less than 12 inches (300 mm) of slack at each end of the pull wire.

N. Telephone and Signal System Raceways 2-Inch Trade Size (DN 53) and Smaller: In addition to the above requirements, install in maximum lengths of 100 feet (30 m) and with a maximum of two 90-degree bends or equivalent. Install pull or junction boxes where necessary to comply with these requirements. Pull or junction boxes shall be sized in accordance with ANSI/EIA/TIA-569A guidelines.

O. Install raceway sealing fittings according to the manufacturer's written instructions. Locate fittings at suitable, approved, accessible locations and fill them with UL-listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points and elsewhere as indicated:

1. Where conduits pass from warm locations to cold locations, such as the boundaries of refrigerated spaces and air-conditioned spaces.

2. Where otherwise required by the NFPA70.

P. Stub-up Connections: Extend conduits through concrete floor for connection to freestanding equipment. Install with an adjustable top or coupling threaded inside for plugs set flush with finished floor. Extend conductors to equipment with rigid steel conduit; FMC may be used 6 inches (150 mm) above the floor. Install screwdriver-operated, threaded plugs flush with floor for future equipment connections.

Q. Flexible Connections: Use maximum of 6 feet (1.8 m) of FMC for recessed and semirecessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for all motors. Use LFMC in wet or damp locations. Install separate ground conductor across flexible connections.

R. Surface Raceways: Install a separate, green, ground conductor in raceways from junction box supplying raceways to receptacle or fixture ground terminals.

S. Set floor boxes level and flush with finished floor surface.

T. Install hinged cover enclosures and cabinets plumb. Support at each corner.

U. Raceways Embedded in Slabs: Embedment of circuitry in field poured concrete slabs and fill will be permitted subject to the approval of the structural engineer, compliance with the "pour schedule" established for the project, and to the following criteria:

1. They shall be routed in such a manner as to coordinate with the structural requirements of the building. Submit proposed routing to structural engineer for approval. Raceways proposed to be embedded in concrete which are not approved by the structural engineer shall be installed in another manner (in accordance with these specifications).

2. Note that embedment of conduit in field poured concrete slabs and/or fill will not be permitted in tenant areas and other spaces where the location of all electrical lighting, power and signal outlets are not shown on the electrical drawings.

3. Maximum outside diameter of raceways shall not exceed one third of concrete thickness. Raceways shall be run in a "single layer" with their outside surface no closer than 1 inch (25mm) to any surface of the concrete.

4. Install in middle 1/3 of slab thickness.

5. Provide support for raceways independent of reinforcing rods.

6. Secure raceways to reinforcing rods to prevent sagging or shifting during concrete placement.

7. Space raceways laterally to prevent voids in the concrete.

8. Run raceway larger than 1 inch (DN 27) trade size parallel to or at right angles to main reinforcement. When at right angles to reinforcement, place raceway close to slab support.

9. They shall not be spaced closer than 3 diameters on center, with a minimum of 3 inches (75mm) between the outside surfaces of the raceways, except at tees, crosses or other single level wide angle junction points.

10. Where crossovers or close groupings are unavoidable, circuitry shall either be dog-legged out of the concrete or be carefully field coordinated so as not to cause structural weakness. Where in metal deck or subfloor type of construction, crossovers shall occur only in valleys.

11. Where turned up or down into a wall or partition they shall, before entering same, be routed parallel for a long enough distance to assure that no relocation of the wall or partition will be necessary to conceal the required bend.

12. They shall be routed in accordance with field instructions issued by the Architect where such instructions differ from specifications set forth herein.

V. To the extent that circuitry cannot be embedded in concrete slabs and fill, floor and wall mounted outlets shall be supplied in conformance with so-called "poke through system" criteria as described below. Outlets supplied from a specialty cast-in-floor raceway system constitute an exception to this criteria.

W. Criteria for the "poke through" system of circuitry are as follows:-

1. Circuitry shall be run in the hung ceiling space of the story which it serves or in the hung ceiling space of the story immediately below, utilizing openings cut through the floor slab when necessary.

2. The running of circuitry, at the story below the one served, shall be held to an absolute minimum, and shall be used only for tying floor outlets to their nearest adjacent outlets or for other such unavoidable purposes.

3. Circuitry serving a given story shall emanate from local supply or central facilities on the same story and none other.

4. Openings through floor slabs shall be cut, patched and "firestopped" as part of the electrical work. "Firestopping" shall include the filling in of excess opening spaces as well as the utilization of approved, fire-rated through-floor fittings for all floor outlets. These fire-rated fittings shall each be of the "dual service" type, complete with integral floor stanchion which can accommodate 120 volt and telephone and/or signal) circuitry and devices. All "firestopping" shall be performed as directed in the field. General instructions establishing cutting, patching and "firestopping" separate from the electric work are not applicable to the poke through system of circuitry.

5. Openings through floor slabs shall not be spaced closer together than 2 feet (61 cm), and no more than one fire-rated fitting per 65 square feet (6 square meters) of floor area in each span shall be utilized.

3.3 LOCATING AND ROUTING CIRCUITRY:

A. All circuitry shall be run concealed except that it shall be run exposed:-

1. Horizontally at the ceiling of permanently unfinished spaces which are not assigned to mechanical or electrical equipment.

2. Horizontally and vertically in mechanical equipment spaces.

3. Horizontally and vertically in electric equipment rooms.

4. Where specifically noted on the drawings.

B. Concealed circuitry shall be so located that building construction materials can be applied over its thickest elements without being subject to spalling or cracking.

3.4 INSTALLING JUNCTION, PULL AND OUTLET BOXES:

A. Apply junction and pull boxes in accordance with the following:-

1. Include pull boxes in long straight runs of raceway to assure that cables are not damaged when they are pulled in.

2. Include junction and pull boxes to assure a neat and workmanlike installation of raceways.

3. Include junction and pull boxes to fulfill requirements pertaining to the limitations to the number of bends permitted in raceway between cable access points, the accessibility of cable joints and splices, and the application of cable supports.

4. Where the wires and cables following the same routing are indicated as running through separate pull boxes, it shall be understood that a segregation of the wires and cables is required. Separately indicated pull boxes may be incorporated into single boxes on condition that segregation is maintained by barriers of the type hereinafter specified.

5. Include all required junction and pull boxes regardless of indications on the drawings (which, due to symbolic methods of notation, may omit to show some of them).

B. Apply outlet boxes in accordance with the following:-

1. Unless noted below or otherwise specifically indicated, include a separate outlet box for each individual wiring device, lighting fixture and signal or communication system outlet component. Outlet boxes supplied attached to lighting fixtures shall not be used as replacements for the boxes specified herein unless they are specifically rated to accept "through circuit" building wires.

2. A continuous row of fixtures of the end-to-end channel type, designed for "through wiring," and wired in accordance with the specifications hereinafter pertaining to circuitry through a series of lighting fixtures, may be supplied through a single outlet box.

3. A series of separate fixtures, designed for "through wiring," spaced not more than 2 feet (600mm) apart, and interconnected with conduit or raceway and circuitry which is in accordance with the specifications hereinafter pertaining to circuitry through a series of lighting fixtures, may be supplied through a single outlet box.

4. Connection to recessed ceiling fixtures supplied with pigtails may be arranged so that more than one, but not more than four, such fixtures are connected into a single outlet box. When adopting this procedure:-

   (a) Utilize an outlet box no smaller than 4-11/16 inches (119mm) square by 2-1/8 inches (54 mm) deep.

   (b) Allow no fixture to be supplied from an outlet box in another room.

5. Multiple local switches indicated at a single location shall be gang mounted in a single outlet box.

6. Include all required outlet boxes regardless of indications on the drawings (which due to symbolic methods of notation, may omit to show some of them).

7. Regardless of any indications on the drawings, flush wall mounted outlet boxes shall not be set back-to-back in fire rated walls or partitions, even if they are displaced vertically. Such outlets shall be offset horizontally by 24 inches (610mm) or as otherwise required to maintain the fire rating.

8. Exclude "through-the-wall" collar type outlet boxes for flush devices

indicated back-to-back in non-fire rated partitions or walls. Where necessary to accommodate box depths, outlets shown back-to-back shall be horizontally offset.

C. Install junction boxes, pull boxes and outlet boxes in accordance with the following:-

1. Exclude surface mounted outlet boxes in conjunction with concealed circuitry.

2. Exclude unused circuitry openings in junction and pull boxes. In larger boxes each such opening shall be closed with a galvanized sheet steel plate fastened with a continuous weld all around. In small outlet type boxes, utilize plugs as specified for such boxes.

3. Close up all unused circuitry openings in outlet boxes. Unused openings in cast boxes shall be closed with approved cast metal threaded plugs. Unused openings in sheet metal boxes shall be closed with sheet metal knock-out plugs.

4. Pack "through the wall" collar type outlet boxes with a sound deadening, non-hardening, non-hygroscopic, non- combustible, high dielectric stuffing material manufactured specifically for the purpose.

5. Outlet boxes for switches shall be located at the strike side of doors. Indicated door swings are subject to field change. Outlet boxes shall be located on the basis of final door swing arrangements.

6. Boxes and plaster covers for duplex receptacles shall be arranged for vertical mounting of the receptacle.

7. Equip outlet boxes used for devices which are connected to wires of systems supplied by more than one set of voltage characteristics with barriers to separate the different systems.

D. Barriers in junction and pull boxes of outlet size shall be of the same metal as the box.

E. Barriers in junction and pull boxes which are larger than outlet size shall be of polyester resin fiberglass of adequate thickness for mechanical strength but in no case less than 1/4 inch (6.5mm). Each barrier shall be mounted, without fastenings, between angle iron guides so that they may be readily removed.

3.5 MOUNTING HEIGHTS

A. Heights of all wall mounted outlets and equipment shall be in accordance with the following list. (Dimensions are above finished floor unless noted.)

1. Receptacle or telephone outlet in field constructed wall, partition or column unless otherwise specified below -- 18 inches (45 cm) to centerline.

2. Receptacle or telephone outlet in factory fabricated wall or partition, unless otherwise specified below -- Dimension determined by wall or partition construction.

3. Receptacle or telephone outlet in mechanical spaces, electric switchboard rooms, electric closets -- 60 inches (150 cm) to centerline.

4. Toggle switch outlet in field constructed wall partition or column -- 46 inches (117 cm) to centerline.

5. Toggle switch outlet in factory fabricated wall or partition -- Dimension determined by wall or partition construction.

6. Bracket lighting outlets, except for "over door" -- 90 inches (228 cm) to centerline.

7. Bracket lighting outlet over door -- as required to center outlet between top surface of door lintel and underside of ceiling.

8. Wall exit sign except for over door -- 90 inches (228 cm) to centerline.

9. Exit sign over door -- As required to center sign between top surface of door lintel and underside of ceiling.

10. Outlet for any signal system device other than fire alarm station requiring manual operation -- 46 inches (117 cm) to centerline.

11. Manual fire alarm station -- 46 inches (117 cm) to centerline.

12. Outlet for any signal system visual or sounding device other than fire alarm visual device or visual/sounding device -- As required for device to clear underside of ceiling by 1 inch (25 mm).

13. Outlet for fire alarm visual device -- Visual device 80 inches (203 cm) AFF, except as otherwise noted.

14. Clock outlet -- As required for clock to clear underside of ceiling by 1 inch (25 mm).

B. Architectural drawings and field instructions issued by the Architect take precedence over the above list and shall be adhered to.

3.6 PROTECTION

A. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, to ensure that coatings, finishes, and cabinets are without damage or deterioration at Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

2. Repair damage to PVC or paint finishes with matching touch-up coating

recommended by the manufacturer.

3.7 CLEANING

A. After completing installation of exposed, factory-finished raceways and boxes, inspect exposed finishes and repair damaged finishes.

END OF SECTION 16130

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 16140 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Single and duplex receptacles, ground-fault circuit interrupters, integral surge suppression units, and isolated-ground receptacles.

2. Single- and double-pole snap switches and dimmer switches.

3. Device wall plates.

4. Floor service outlets, poke-through assemblies, and multioutlet assemblies.

1.3 DEFINITIONS

A. GFCI: Ground-fault circuit interrupter.

B. EMI: Electromagnetic interference.

C. RFI: Radio-frequency interference.

D. TVSS: Transient voltage surge suppressor.

E. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of wiring device through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NFPA 70, as amended by state and local codes.

1.6 COORDINATION

A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Wiring Devices:

(a) Bryant Electric, Inc./Hubbell Subsidiary.

(b) Hubbell Incorporated; Wiring Device-Kellems.

(c) Leviton Mfg. Company Inc.

(d) Pass & Seymour/Legrand; Wiring Devices Div.

2. Wiring Device type Lighting Dimmers:

(a) Lutron.

(b) Lightolier.

3. Wiring Devices for Hazardous (Classified) Locations:

(a) Crouse-Hinds/Cooper Industries, Inc.; Arrow Hart Wiring Devices.

(b) EGS/Appleton Electric Company.

(c) Killark Electric Manufacturing Co./Hubbell Incorporated.

4. Multioutlet Assemblies:

(a) Hubbell Incorporated; Wiring Device-Kellems.

(b) Wiremold Company (The).

5. Poke-Through, Floor Service Outlets and Telephone/Power Poles:

(a) Hubbell Incorporated; Wiring Device-Kellems.

(b) Pass & Seymour/Legrand; Wiring Devices Div.

(c) Square D/Groupe Schneider NA.

(d) Thomas & Betts Corporation.

(e) Wiremold Company (The).

2.2 RECEPTACLES

A. Receptacles: NEMA WD 6, Comply with NEMA WD 1, Federal Specification WC 596, and UL 498. Rectangular (decorator) style in public spaces.

B. Straight-Blade and Locking Receptacles: Commercial specification grade, configuration 5-20R.

C. GFCI Receptacles: Straight blade type, Commercial specification grade, with integral NEMA WD 6, Configuration 5-20R duplex receptacle; complying with UL 498 and UL 943. Design units for installation in a 2-3/4-inch- (70-mm-) deep outlet box without an adapter. Incorporate "through feed" features permitting the optional protection of downstream receptacles if desired.

D. Isolated-Ground Receptacles: Straight blade, Commercial specification grade, duplex receptacle, with equipment grounding contacts connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap.

1. Devices: Listed and labeled as isolated-ground receptacles.

2. Isolation Method: Integral to receptacle construction and not dependent on removable parts.

E. TVSS Receptacles: Straight blade, NEMA WD 6, Configuration 5-20R, with integral TVSS in line to ground, line to neutral, and neutral to ground.

1. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp level rating of 500 volts and minimum single transient pulse energy dissipation of 140 J line to neutral, and 70 J line to ground and neutral to ground.

2. Active TVSS Indication: Visual only with light visible in face of device to indicate device is "active" or "no longer in service."

2.3 SWITCHES

A. Single- and Double-Pole Switches: Comply with NEMA WD 1 and WD 6, Federal Specification WS-896, and UL 20. Rectangular (decorator) style in public spaces.

1. Snap Switches: Heavy-Duty grade, quiet type.

2. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on/off switches and audible frequency and EMI/RFI filters.

(a) Control: Continuously adjustable; with single-pole or three-way switching to suit connections.

(b) Incandescent Lamp Dimmers: Modular, 120 V, 60 Hz with continuously adjustable rotary knob, toggle switch, or slider; single pole with soft tap or other quiet switch; EMI/RFI filter to eliminate interference; and 5-inch (130-mm) wire connecting leads. Suitable for use with magnetic or electronic low voltage lamp transformers as required to suit load.

(c) Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.4 WALL PLATES

A. Single and combination types with openings to match corresponding wiring devices. Comply with NEMA WD 1 and WD 6.

1. Plate-Securing Screws: Metal with head color to match plate finish.

2. Material for Finished Spaces: as indicated by architect

3. Material for Unfinished Spaces: Galvanized steel Smooth.

4. Material for Wet Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations." Enclosures for 120 Volt receptacles rated 20 Amperes or less are weatherproof whether or not the attachment plug cap is inserted.

2.5 FLOOR SERVICE FITTINGS

A. Type: Modular **[flush-type] [flap-type] [above-floor]**, dual-service units suitable for wiring method used.

B. Compartments: Barrier separates power from voice and data communication cabling.

C. Service Plate: **[Rectangular] [Round],** [**die-cast aluminum] [solid brass]** with satin finish.

D. Power Receptacle: NEMA WD 6, Configuration 5-20R, gray finish, unless otherwise indicated.

2.6 POKE-THROUGH ASSEMBLIES

A. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.

1. Service Outlet Assembly: **[Pedestal type with services indicated] [Flush type with two simplex receptacles and space for two Category 5 RJ-45 jacks] [Flush type with four simplex receptacles and space for four Category 5 RJ-45 jacks.]**

2. Furniture feed type service assembly: **[Pedestal] [Flush]** type with connections for power and communications.

3. Size: Selected to fit nominal **[3-inch (75-mm)] [4-inch (100-mm)]** cored holes in floor and matched to floor thickness.

4. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.

5. Closure Plug: Arranged to close unused 3-inch (75-mm) 4-inch (100-mm) cored openings and reestablish fire rating of floor.

6. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors; and a minimum of four, 4-pair, Category 5 voice and data communication cables.

2.7 MULTIOUTLET ASSEMBLIES

A. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

1. Raceway Material: Metal, with manufacturer's standard finish.

2. Wire: No. 12 AWG.

2.8 FINISHES

A. Color:

1. Wiring Devices Connected to Normal Power System: As selected by Architect from manufacturer’s standard colors, unless otherwise indicated or required by NFPA 70.

2. Wiring Devices Connected to Emergency Power System: Red.

3. Isolated-Ground Receptacles: Orange

4. Comply with NEMA WD 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install devices and assemblies level, plumb, and square with building lines.

B. Install wall dimmers to achieve indicated rating after derating for ganging according to manufacturer's written instructions.

C. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' written instructions.

D. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical, and with grounding terminal of receptacles on top. Group adjacent devices under single, multigang wall plates.

E. Remove wall plates and protect devices and assemblies during painting.

F. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

A. Comply with Division 16 Section "Electrical Identification."

1. Receptacles Connected to Emergency Power System: Identify panelboard and circuit number from which served. Use hot stamped or engraved machine printing with red-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.3 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing wiring devices and after electrical circuitry has been energized, test for proper polarity, ground continuity, and compliance with requirements.

2. Test GFCI operation with both local and remote fault simulations according to manufacturer's written instructions.

B. Remove malfunctioning units, replace with new units, and retest as specified above.

END OF SECTION 16140

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 16145 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following lighting control devices:

1. Time switches.

2. Photoelectric switches.

3. Occupancy sensors.

4. Multipole contactors.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for wall-box dimmers and manual light switches.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.5 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Lighting control devices have been specified on the drawings and in other Division 16 Sections. Where they introduce lists, the following requirements apply to product selection:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.2 GENERAL LIGHTING CONTROL DEVICE REQUIREMENTS

A. Line-Voltage Surge Protection: An integral part of the devices for 120- and 277-V solid-state equipment. For devices without integral line-voltage surge protection, field-mounting surge protection shall comply with IEEE C62.41 and with UL 1449.

2.3 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG, complying with Division 16 Section "Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded copper conductors not smaller than No. 18 AWG, complying with Division 16 Section "Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded copper conductors not smaller than No. 14 AWG, complying with Division 16 Section "Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve at least 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

A. Wiring Method: Comply with Division 16 Section "Conductors and Cables." Minimum conduit size shall be 3/4 inch trade size (DN21).

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.

D. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

F. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 IDENTIFICATION

A. Identify components and power and control wiring according to Division 16 Section Electrical Identification."

B. Label time switches and contactors with a unique designation.

3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.

2. Operational Test: Verify actuation of each sensor and adjust time delays.

B. Remove and replace lighting control devices where test results indicate that they do not comply with specified requirements.

C. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.5 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to site outside normal occupancy hours for this purpose.

END OF SECTION 16145

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SECTION 16190 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes secure support from the building structure for electrical items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.

B. Related sections include the following:

1. Refer to other Division 16 sections for additional specific support requirements that may be applicable to specific items.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product data for each type of product specified.

1.4 QUALITY ASSURANCE

A. Electrical Component Standard: Components and installation comply with NFPA 70, as amended by state and local codes.

B. Electrical components are listed and labeled by UL, ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Slotted Metal Angle and U-Channel Systems:

(a) B-Line Systems, Inc.

(b) Haydon Corp.

(c) Kin-Line, Inc.

(d) Unistrut Diversified Products

2. Conduit Sealing Bushings:

(a) Cooper Industries, Inc.

(b) L.E. Mason Co.

(c) O-Z/Gedney

(d) Raco, Inc.

(e) Spring City Electrical Mgf. Co.

(f) Thomas & Betts Corp.

2.2 COATINGS

A. Coating: Supports, support hardware, and fasteners are protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors are hot-dip galvanized.

2.3 MANUFACTURED SUPPORTING DEVICES

A. Raceway Supports: Clevis hangers, riser clamps, conduit straps, threaded C-clamps with retainers, ceiling trapeze hangers, wall brackets, and spring steel clamps.

1. Fasteners: Types, materials, and construction features as follows:

2. Expansion Anchors: Carbon steel wedge or sleeve type.

3. Toggle Bolts: All steel springhead type.

B. Powder-Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.

C. Conduit Sealing Bushings: Factory-fabricated watertight conduit sealing bushing assemblies suitable for sealing around conduit, or tubing passing through concrete floors and walls. Construct seals with steel sleeve, malleable iron body, neoprene sealing grommets or rings, metal pressure rings, pressure clamps, and cap screws.

D. Cable Supports for Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug for nonarmored electrical cables in riser conduits. Provide plugs with number and size of conductor gripping holes as required to suit individual risers. Construct body of malleable-iron casting with hot-dip galvanized finish.

E. U-Channel Systems: 16-gauge steel channels, with 9/16-inch (14 mm) diameter holes, at a minimum of 8 inches (20 cm) on center, in top surface. Provide fittings and accessories that mate and match with U-channel and are of the same manufacture.

2.4 FABRICATED SUPPORTING DEVICES

A. General: Shop- or field-fabricated supports or manufactured supports assembled from U-channel components.

B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

C. Pipe Sleeves: Provide pipe sleeves of one of the following:

1. Sheet Metal: Fabricate from galvanized sheet metal; round tube closed with snaplock joint, welded spiral seams, or welded longitudinal joint. Fabricate sleeves from the following gauge metal for sleeve diameter noted:

(a) 3 inch (8 cm) and smaller: 20-gauge.

(b) 4 inch (10 cm) to 6-inch (15 cm): 16-gauge.

(c) over 6-inch (15 cm): 14-gauge.

2. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe.

3. Plastic Pipe: Fabricate from Schedule 80 PVC plastic pipe.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install supporting devices to fasten electrical components securely and permanently in accordance with Electrical Code requirements.

B. Coordinate with the building structural system and with other electrical installation.

C. Raceway Supports: Comply with NFPA 70, as amended by state and local codes, and the following requirements:

1. Conform to manufacturer's recommendations for selection and installation of supports.

2. Strength of each support is adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 lbs (90 kg), provide additional strength until there is a minimum of 200 lbs (90 kg) safety allowance in the strength of each support.

3. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.

4. Support parallel runs of horizontal raceways together on trapeze-type hangers.

5. Support individual horizontal raceways by separate pipe hangers. Spring steel fasteners may be used in lieu of hangers only for 1-1/2-inch (DN 41) and smaller raceways serving lighting and receptacle branch circuits above suspended ceilings only. For hanger rods with spring steel fasteners, use 1/4 inch (6 mm) diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.

6. Support exposed and concealed raceway within 1 foot (30 cm) of an unsupported box and access fittings. In horizontal runs, support at the box and access fittings may be omitted where box or access fittings are independently supported and raceway terminals are not made with chase nipples or threadless box connectors.

7. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on conductor terminals.

D. Vertical Conductor Supports: Install simultaneously with installation of conductors.

E. Miscellaneous Supports: Support miscellaneous electrical components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes, junction boxes, transformers, and other devices.

F. In open overhead spaces, cast boxes threaded to raceways need not be supported separately except where used for fixture support; support sheet metal boxes directly from the building structure or by bar hangers. Where bar hangers are used, attach the bar to raceways on opposite sides of the box and support the raceway with an approved type of fastener not more than 24 inches (60 cm) from the box.

G. Sleeves: Install in concrete slabs and walls and all other fire- rated floors and walls for raceways and cable installations. For sleeves through fire rated-wall or floor construction, apply UL- listed firestopping sealant in gaps between sleeves and enclosed conduits and cables in accordance with "Firestopping" requirement of Division 16 Section "Basic Electrical Materials and Methods."

H. Conduit Seals: Install seals for conduit penetrations of slabs on grade and exterior walls below grade and where indicated. Tighten sleeve seal screws until sealing grommets have expanded to form watertight seal.

I. Fastening: Unless otherwise indicated, fasten electrical items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, busways, cabinets, panelboards, transformers, boxes, disconnect switches, and control components in accordance with the following:

1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut to depth of more than 1-1/2 inches (4 cm) in reinforced concrete beams or to depth of more than 3/4 inch (2 cm) in concrete do not cut the main reinforcing bars. Fill holes that are not used.

3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock- resistant fasteners for attachments to concrete slabs.

J. In general, walls and partitions are not suitable for supporting the weight of panelboards, dry type transformers and the like. Include supporting frames or racks extending from floor slab to ceiling slab for all such items unless specifically instructed otherwise by the Architect.

K. Include supporting frames or racks for equipment, intended for vertical surface mounting, which is required in a free standing position.

L. Supporting frames or racks are of standard angle, standard channel or specialty support system steel members. They are rigidly bolted or welded together and adequately braced to form a substantial structure. Racks are of ample size to assure a workmanlike arrangement of all equipment mounted on them.

M. No work intended for exposed installation in damp locations is mounted directly on any building surface. In such locations, flat bar members or spacers are used to create a minimum of 1/4 inch (6 mm) air space between the building surfaces and the work.

N. Support vertical runs of bus duct at intervals no greater than the floor to floor height, or 13 feet (4 m), whichever is smaller. Support horizontal runs of bus duct at intervals no greater than 5 feet (150 cm).

O. Nothing (including outlet, pull and junction boxes and fittings) depends on electric conduits, raceways or cables for support except that threaded hub type fittings having a gross volume not in excess of 100 cubic inches (1600 cc) may be supported from heavy wall conduit, where the conduit in turn is securely supported from the structure within 5 inches (12 cm) of the fitting on two opposite sides.

P. Nothing rests on, or depends for support on, suspended ceiling media (tiles, lath, plaster, as well as splines, runners, bars and the like in the plane of the ceiling). Vertical members which suspend the ceiling (together with their horizontal bracing which occurs above the ceiling), however, may be used for support, subject to the following criteria:

1. Supporting procedures are in accordance with the ceiling system manufacturer's instructions.

2. Supporting members for circuitry are rigid. Wires may not be used for such supports.

3. The ceiling is not fire rated.

Q. In conjunction with lighting fixtures or other items weighing less than 40 pounds (18 kg), the above restriction against supporting from suspended ceiling splines, runners or bars in the plane of the ceiling may be waived for ceilings which have been specifically approved for the weight and arrangement of fixtures being applied. Any support members, mechanical fastening means (i.e., bolts, screws or rivets), or other appurtenances, however, required to tie in or adapt to the fixtures and their ceiling opening frames (if any) to the ceiling in the approved manner are included as part of the electric work.

R. As a minimum procedure, support surface or pendant mounted lighting fixture:-

1. From its outlet box by means of an interposed metal strap, where weight is less than 5 pounds (2 kg).

2. From its outlet box by means of a hickey or other direct threaded connection, where weight is from 5 pounds (2 kg) to 50 pounds (20 kg).

3. Directly from structural slab, deck or framing member, where weight exceeds 50 pounds (20 kg).

S. As a minimum procedure, support recessed lighting fixtures as follows:

1. From ceiling suspension members, as described above, <u>where weight is 80 pounds (35 kg) or less</u>. Fluorescent fixtures are provided with clips to secure the fixtures to the ceiling members at two opposite ends of each fixture.

2. Directly from structural slabs, decks or framing members where weight is more than 80 pounds (35 kg).

T. Include in the electric work channel sills or skids for leveling and support of all floor mounted electrical equipment.

U. Where permitted loading is exceeded by direct application of electrical equipment to a slab or deck, include in the electric work proper dunnage as required to distribute the weight in a safe manner.

END OF SECTION 16190

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SECTION 16231 - PACKAGED ENGINE GENERATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes packaged engine generator set(s) with the following features and accessories:

1. Engine generator set.

2. **[Fuel tank] [Day tank].**

3. Starting battery.

4. Battery charger.

5. Remote stop switch.

6. Muffler.

7. Outdoor enclosure.

8. Remote annunciator.

B. Related Sections include the following:

1. Division 16 Section "Transfer Switches" for transfer switches, including sensors and relays to initiate automatic-starting and -stopping signals for engine generator sets.

1.3 DEFINITIONS

A. Standby Rating: Power output rating equal to the power the generator set delivers continuously under normally varying load factors for the duration of a power outage.

B. Operational Bandwidth: The total variation from the lowest to the highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

C. Steady-State Voltage Modulation: The uniform cyclical variation of voltage within the operational bandwidth, expressed in Hz or cycles per second.

1.4 SUBMITTALS

A. Product Data: Include data on features, components, ratings, and performance. Include the following:

1. Dimensioned outline plan and elevation drawings of engine generator set and other components specified.

2. Thermal damage curve for generator.

3. Time-current characteristic curves for generator protective device.

B. Shop Drawings: Indicate fabrication details, dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Design Calculations: Signed and sealed by a qualified professional engineer. Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.

2. Vibration Isolation Base Details: Signed and sealed by a qualified professional engineer. Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include base weights.

3. Wiring Diagrams: Detail wiring for power and control connections and differentiate between factory-installed and field-installed wiring.

C. Qualification Data: For firms specified in "Quality Assurance" Article.

D. Field Test and Observation Reports: Indicate and interpret test results and inspection records relative to compliance with performance requirements.

E. Certified Summary of Performance Tests: Demonstrate compliance with specified requirement to meet performance criteria for sensitive loads.

F. Factory Test Reports: For units to be shipped for this Project, showing evidence of compliance with specified requirements.

G. Exhaust Emissions Test Report: To show compliance with applicable regulations.

H. Sound Measurement Test Report: To show compliance with applicable regulations.

I. Certification of Torsional Vibration Compatibility: Comply with NFPA 110.

J. Field test report of tests specified in Part 3.

K. Maintenance Data: For each packaged engine generator and accessories to include in maintenance manuals specified in Division 1. Include the following:

1. Detail operating instructions for both normal and abnormal conditions.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Maintain a service center capable of emergency maintenance and repairs at the Project site with 8 hours maximum response time.

B. Source Limitations: Obtain engine generator set and auxiliary components specified in this Section through one source from a single manufacturer with the responsibility for the entire system.

C. Electrical Components, Devices and Accessories: Underwriters Laboratories listed or labeled.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

D. Comply with NFPA 70, as amended by state and local codes.

E. Comply with NFPA 110 requirements for a Level 1 emergency power supply system.

F. Comply with UL 2200, listed and labeled.

G. Engine Exhaust Emissions: Comply with applicable federal, state and local government requirements, including published requirements which will be in effect at the date of system commissioning.

H. Noise Emission: Comply with applicable federal, state and local government requirements due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver engine generator set and system components to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and prevent damage from construction operations. Remove protection only after equipment is safe from such hazards.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Caterpillar, Inc.; Engine Division.

2. Mitsubishi, Inc.

3. Kohler Company; Generator Division.

4. Detroit Diesel.

5. Cummins Power Generation.

2.2 ENGINE GENERATOR SET

A. Furnish a coordinated assembly of compatible components.

B. Ratings: Voltage and power output ratings of system shall be as indicated. Frequency shall match utility service frequency unless otherwise indicated. Unit shall supply its indicated KW power load at power factors down to 80 percent.

C. Output Connections: 3 phase, 4 wire.

D. Safety Standard: Comply with ASME B15.1.

E. Nameplates: Each major system component shall be equipped with a conspicuous nameplate of component manufacturer. Nameplate shall identify manufacturer of origin and address, and model and serial number of item.

F. Limiting dimensions indicated for system components shall not be exceeded.

G. Power Output Rating: Nominal ratings shall be as indicated, with capacity as required to operate as a unit as evidenced by records of factory testing.

H. Emissions and Noise: Emissions and Noise shall be in compliance with all applicable criteria regarding environmental pollution of all agencies having jurisdiction

I. Skid: Adequate strength and rigidity to maintain alignment of mounted components without dependence on a concrete foundation. Skid shall be free from sharp edges and corners. Lifting attachments shall be arranged to facilitate lifting with slings without damaging any components.

J. The engine-generator set(s), including radiator, shall be provided with a structural steel base. The base shall have sufficient rigidity for spring type isolators in quantities as required between enclosure floor and generator. Mounting shall incorporate a leveling device, vertical stops and three layers of neoprene acoustical pad, with each layer separated by a steel plate. The mountings shall be installed directly under the structural steel base and positioned to accept the weight and weight distribution for uniform mounting deflection. Spring isolators shall provide a minimum static deflection of 2 inches (5 cm) and shall be similar to Mason Industries, Inc., Type SLR or as approved. Neoprene pads shall be similar to Mason Industries Type W, or as approved.

2.3 GENERATOR-SET PERFORMANCE, NOMINAL

A. The emergency generator set and associated controls and appurtenances shall be suitable for use where up to 33 percent of the total load to be supplied are non-linear loads .

B. Steady-State Voltage Operational Bandwidth: 4 percent of rated output voltage from no load to full load.

C. Steady-State Voltage Modulation Frequency: Less than one Hz.

D. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover to remain within the steady-state operating band within 2 seconds. Unit shall accept a one-step application of 100 percent of specified load rating without causing the engine to stall.

E. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

F. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

G. Transient Frequency Performance: Less than 2-Hz variation for a 50 percent step-load increase or decrease. Frequency shall recover to remain within the steady-state operating band within 3 seconds.

H. Output Waveform: At no load, harmonic content measured line-to-line or line-to-neutral shall not exceed 5 percent total and 3 percent for single harmonics. The telephone influence factor, determined according to NEMA MG 1, shall not exceed 50.

I. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at the system output terminals, the system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to any generator system component.

J. Temperature Rise of Generator: Not more than 115 deg C over a 40 deg C ambient, as measured by resistance, NEMA MG 1 when operating continuously at full-rated load.

K. Starting Time: Maximum total time period for a cold start, with ambient temperature at the low end of the specified range, shall be 8 seconds. Time period shall include output voltage and frequency settlement within specified steady-state bands.

2.4 SERVICE CONDITIONS

A. Environmental Conditions: Engine generator system shall withstand the following

environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 35 deg C to plus 50 deg C

2. Altitude: Sea level to 1485 feet (453 m)

2.5 ENGINE

A. Comply with NFPA 37.

B. Fuel: Diesel fuel oil grade DF-2.

C. Maximum Engine Speed: 1800 rpm.

D. Maximum Piston Speed for 2-Cycle Engines: 1725 fpm (880 cm/s).

E. Maximum Piston Speed for 4-Cycle Engines: 2250 fpm (1140 cm/s).

F. Lubrication System: Pressurized by a positive-displacement pump driven from engine crankshaft. The following items shall be mounted on the engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 microns and smaller while passing full flow.

2. Oil Cooler: Maintains lubricating oil at manufacturer's recommended optimum temperature.

3. Thermostatic Control Valve: Controls flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and shall be designed to be fail-safe.

4. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without the use of pumps or siphons or special tools or appliances.

G. Engine Fuel System: Comply with NFPA 37. System includes the following:

1. Integral Injection Pumps: Driven by engine camshaft. Pumps shall be adjustable for timing and cylinder pressure balancing.

2. Main Fuel Pump: Mounted on engine. Pump shall ensure adequate primary fuel flow under starting and load conditions.

3. Fuel Oil Filters: Primary and secondary. Primary filter shall include water separator.

4. Relief/Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

5. Integrally mounted, electric motor driven, air cooled fuel oil cooler, complete with electric supply tapped from generator control panel. Radiator cooled unit will not be acceptable unless manufacturer certifies that radiator has

been sized to accommodate this additional load. Cooler shall limit maximum engine fuel inlet temperature with engine running continuously at full load as required by engine manufacturer.

H. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

2.6 GOVERNOR

A. Type: Adjustable electronic isochronous type, with speed droop provisions.

2.7 ENGINE COOLING SYSTEM

A. Description: Closed loop, liquid cooled, with radiator factory mounted on engine generator-set skid and integral engine-driven coolant pumping.

B. Radiator: Rated for specified coolant. Airflow shall be less than 100 CFM (170 cubic meters per hour) per kilowatt of certified load.

1. Radiator Core Tubes: Nonferrous-metal construction other than aluminum.

2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.

3. Fan: Driven by multiple belts from engine shaft. Unit shall be sized to deliver required air flow with at least 1/2 inch water column (.12 kPa) static pressure plus drop within radiator.

C. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anti-corrosion additives as recommended by engine manufacturer.

D. Temperature Control: Self-contained, thermostatic-control valve shall modulate coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

E. Coolant Hose: Flexible assembly with nonporous rubber inside surface and aging, ultraviolet, and abrasion-resistant fabric outer covering.

1. Rating: 50-psig (345-kPa) maximum working pressure with 180 deg F (82 deg C) coolant, and noncollapsible under vacuum.

2. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

2.8 FUEL SUPPLY SYSTEM

A. Comply with NFPA 30 and NFPA 37.

B. **Day Tank: Factory-fabricated and installed assembly of a listed fuel tank with integral floats for control of transfer pump, and features as listed below. If tank is not factory installed, field installation of day tank on or adjacent to**

engine base will be acceptable. Include piping, solenoid valves and other appurtenances between day tank and engine as part of the electrical work.

1. Containment: Integral rupture basin with a capacity of 200 percent of nominal capacity of day tank. Epoxy coated interior, oil resistant enamel exterior finish.

(a) Leak Detector: Locate in rupture basin. Dry contact closure for connection to fuel oil management control panel, plus additional dry contact closure for connection to BMS system, in the event of a day-tank leak. Switch shall be sealed against vapors and fluids, be lever float operated, and magnetically actuated. Wiring enclosure shall be cast aluminum NEMA 4 construction.

2. Tank Capacity: 2000 gallons (7571 liters).

3. **Unit, Including Pump Control Float and Alarm Contacts: Comply with UL 142.**

4. **Pump Control Float Contacts: Activates pump at 50 percent of normal fuel capacity and deactivates pump at 80 percent of normal fuel capacity.**

5. **Secondary Pump Control Float Contacts: Activates secondary pump plus dry contact closure for connection to fuel oil management control panel at 40 percent of normal fuel capacity.**

6. **Low-Level Alarm Sensor: Separate device shall operate dry contact closure for connection to fuel oil management control panel at 20 percent of normal fuel capacity.**

7. **High-Level Alarm Sensor: Separate device shall operate dry contact closure for connection to fuel oil management control panel and redundant fuel shutoff contacts at 90 percent of normal fuel capacity. Shutoff also shall close a solenoid valve in fuel suction line from fuel storage tank to day tank. Both items shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to fuel oil management control panel plus dry contact closure for connection to BMS, but shall not shut down engine generator set.**

8. **Control Probe: Suitable for pressures to 150 psi (1000 kPa). Constructed entirely of non-ferrous material. Electrical connections shall be external to tank in cast aluminum NEMA 4 enclosure.**

C. **Base-Mounted Fuel Oil Tank: Factory-installed and -piped, listed and labeled fuel oil tank. Features shall include the following:**

1. **Double walled tank with integral leak detection with dry contact closure for connection to BMS.**

2. **Tank level indicator.**

3. **Capacity: Fuel for 8 hours of continuous operation at 100 percent rated power output.**

4. **Vandal-resistant fill cap.**

5. **Tank shall be vented to the outside of the enclosure with a minimum of a two inch pipe with appropriate ball plunger type apparatus which will only allow fumes to be released to the atmosphere and not liquids.**

D. **Fuel Oil Piping and Remote Fuel Oil Storage Tank: Provided as part of Division 15 Work, complete with main fuel transfer pump, piping from storage tank to day tank, and all required valves and appurtenances.**

E. Interior Fuel Oil Piping: Include required field installed piping between the day tank

and the engine. Refer to Division 15 specifications for materials and installation.

2.9 ENGINE EXHAUST SYSTEM

A. Muffler: Critical type, sized as recommended by engine manufacturer. Measured sound level at a distance of 10 feet (3 m) from the exhaust discharge, shall be 85 dBA or less. Muffler shall be sized so that engine will be capable of delivering its rated output with a friction head back pressure of up to 3/4 inches of mercury (2.5 kPa) in the exhaust pipe extension from the output side of the muffler (i.e., excluding the drop in the muffler).

B. Connections from Engine to Exhaust System: Flexible section of corrugated stainless-steel pipe.

C. Supports of Muffler and Exhaust Piping: Spring hangers and all-thread rods as specified in Division 15 Section “Vibration Control”; attached to generator housing.

D. Exhaust Piping External to Engine: Welded joints and fittings

E. Thimbles for Exhaust Piping: Comply with NFPA 211.

2.10 AIR INTAKE AND EXHAUST SYSTEM

A. All required material and appurtenances

2.11 STARTING SYSTEM

A. Description: 24-V electric, with negative ground and including the following items:

1. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Environmental Conditions" Paragraph above.

2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

3. Cranking Cycle: As required by NFPA 110 for Level 1 systems.

4. Battery : Adequate capacity within ambient temperature range specified in "Service Conditions" Paragraph above to provide specified cranking cycle at least twice without recharging.

5. Battery Cable: Size as recommended by generator set manufacturer for cable length. Include required interconnecting conductors and connection accessories.

6. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage-regulation and 35-A minimum continuous rating.

7. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 508 and shall include the following features:

(a) Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then automatically switch to a lower float-charging mode and continue operating in that mode until battery is discharged again.

(b) Automatic Temperature Compensation: Adjusts float and equalizes voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.

(c) Automatic Voltage Regulation: Maintains output voltage constant regardless of input voltage variations up to plus or minus 10 percent.

(d) Ammeter and Voltmeter: Flush mounted in charger enclosure. Meters shall indicate charging rates.

(e) Safety Functions: Include sensing of abnormally low battery voltage arranged to close contacts providing low battery voltage indication on control and monitoring panel. Also include sensing of high battery voltage and loss of AC input or DC output of battery charger. Either of these conditions shall close a set of dry contacts that provide a battery charger malfunction indication at system control and monitoring panel and a dry contact closure for connection to BMS.

(f) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

2.12 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches shall initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set shall start. The off position of same switch shall initiate generator-set shutdown. When generator set is running, specified system or equipment failures or derangements shall automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch shall also shut down generator set.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position shall start generator set. The off position of same switch shall initiate generator-set shutdown. When generator set is running, specified system or equipment failures or derangements shall automatically shut down generator set and initiate alarms. Operation of a remote emergency-stop switch shall also shut down generator set.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped on a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

(a) Current and potential transformers: Instrument accuracy class.

D. Indicating and Protective Devices, and Controls: Include those required by NFPA 110 for a Level 1 system, plus the following:

1. Ac voltmeter.

2. Ac ammeter.

3. Ac frequency meter.

4. Dc voltmeter (alternator battery charging).

5. Engine-coolant temperature gage.

6. Engine lubricating-oil pressure gage.

7. Running-time meter.

8. Ammeter-voltmeter, phase-selector switch or switches.

9. Generator-voltage adjusting rheostat.

E. Supporting Items: Include sensors, transducers, terminals, relays, and other devices, and wiring required to support specified items. Locate sensors and other supporting items on engine, generator, or elsewhere to suit manufacturer's standard.

F. Connection to Data Link: A Mod-Bus compatible interface for all monitoring and alarm functions. Also provide a separate terminal block, factory wired to Form “C” dry contacts, for each alarm and status indication for connections for data link transmission of indications to remote data terminals.

G. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel for connection to BMS.

1. Engine high-temperature shutdown.

2. Lube-oil low-pressure shutdown.

3. Overspeed shutdown.

4. Remote emergency-stop shutdown.

5. Engine high-temperature prealarm.

6. Lube-oil low-pressure prealarm.

7. Fuel tank low level.

8. Overcrank shutdown.

9. Coolant low-temperature alarm.

10. Control switch not in auto position.

11. Battery-charger malfunction alarm.

12. Battery low-voltage alarm.

H. Remote Alarm Annunciator / Control: An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing initiating condition will reactivate alarm until silencing switch is reset. Include manual Hand-Off-Auto control switch to control operation of generator. Cabinet and faceplate shall be surface- or flush-mounting type to suit mounting conditions indicated. Install at fire command center or location as directed, complete with all required circuitry.

I. Remote Emergency-Stop Switch: Multipole emergency generator break-glass switch, in NEMA 3R enclosure located at the exterior of the generator enclosure at strike side of the main door. Provide nameplate to read "Emergency Generator Emergency Shutdown and Stop of Fuel Oil Flow". Activation of break-glass switch to shut down fuel supply to the engine [**and day tank (from main pumps)]** with spare dry contact for connection to BMS. Install complete with circuitry.

2.13 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices: Generator overcurrent devices and other indicated components shall be grouped in a separately mounted generator power panel. Devices serving Elevators and “Emergency” System and “Legally Required Standby System” loads other than fire pumps shall be fully coordinated with downstream devices, and shall be switch and fuse type if required in order to achieve this coordination. Other devices shall be circuit breaker type. Panel features shall include:

1. Generator Circuit Breakers: Molded case or insulated case type conforming to Division 16 Section "Selection of Overcurrent Devices" with suitable interrupting capacity.

   (a) Feeder Overcurrent Devices: with ratings as indicated on drawings. Instantaneous trip settings shall be adjustable.

2. Generator Switch and Fuse Devices: Fusible switching devices conforming to Division 16 Section "Selection of Overcurrent Devices" with suitable interrupting capacity.

   (a) Feeder Overcurrent Devices: with ratings as indicated on drawings.

3. Ground Fault: Sensors plus alarm relay. Automatic tripping shall not be provided. Integrate ground-fault alarm indication with other generator-set alarm indications.

2.14 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and specified performance requirements.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction prevents mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 100 percent of rated capacity.

F. Excitation shall use no slip or collector rings, or brushes, and shall be arranged to sustain generator output under short-circuit conditions as specified.

G. Enclosure: Dripproof.

H. The generator together with its associated voltage regulator, exciter, instrumentation and controls shall be of a type which shall be suitable for applications where the load to be supplied consists of substantial amounts of non-linear (i.e., harmonic producing) equipment. Isolation transformers, complete with filtering equipment, shall be provided to minimize the effect of distortion on the voltage regulator power supply and sensing circuits, on governor control and supply circuits, on instrumentation and relaying and on other voltage sensing components. Voltage and current sensing devices shall sense true RMS values, and frequence sensing devices shall sense zero crossover.

I. Excitation System: Generator shall be equipped with a permanent magnet generator excitation system. The output of the PMG shall be used to supply power to the voltage regulator and to effectively isolate the regulator power circuits from the distortion that occurs when the generator supplies large non-linear loads. Under short circuit conditions, system shall be capable of sustaining 300 percent of rated current for 10 seconds. Rotating rectifier shall use a three phase full wave rectifier assembly with hermetically sealed silicon diodes protected against abnormal transient conditions by a surge protector.

J. Voltage Regulator: Completely solid state with electronic components encapsulated for protection against vibration and atmospheric deterioration. The regulator includes three phase RMS sensing, true volts per hertz operation with adjustable cut in, and provisions for parallel operation.

1. A voltage adjusting rheostat shall be provided on the control panel to permit a ± 10 percent adjustment in generator voltage.

2. The voltage regulator also includes circuits that provide loss of sensing voltage shutdown and overexcitation shutdown with inverse time characteristic to protect the generator and the connected load from abnormal voltages. Loss of sensing shutdown does not activate if a short circuit condition were to occur.

K. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

L. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

2.15 OUTDOOR GENERATOR SET ENCLOSURE (WALK-IN)

A. Weatherproof, walk-in type, sound attenuating enclosure which limits the sound as required to comply with applicable sound restrictions, but in any case to no more than 85 dBA as measured at 3 feet (90 cm) from any side, top or bottom, under all operating conditions. Appropriate sound baffling and insulation shall be applied to achieve this designated sound level. The exterior four sides of the enclosure shall be free of louvers, dampers, sound traps, etc. Air intake shall be from below, air discharge from top.

B. Construction:

1. Exterior shall be 4 inch (10 cm) thick panels of bolted together construction.

2. All panel exterior surfaces shall be of aluminum, finished in a color as selected.

3. All interior perforated surfaces shall be aluminum.

4. Each panel includes aluminum framing with studs no more than 24 inches (60 cm) on center. Stiffened wall panels shall not exceed 24 inches (60 cm) in width.

5. The panel cores shall be 100 percent filled with fireproof mineral fiber sound-absorbing material.

6. The enclosure shall be sized as required with a minimum of 2 feet (60 cm) of working space all around, and with a minimum of 42 inches (100 cm) at electrical connections). The enclosure shall include multiple 36 inch (90 cm) wide by 80 inch (200 cm) high prehung, full 2 inch (50 cm) thick, insulated soundproof doors, fully gasketed all around on all four (4) flanged edges. The doors shall be industrial type for severe service. Doors shall be constructed and detailed to maintain the maximum sound level as specified above outside enclosure.

7. Provide stairs complete with platforms, railings, and handrails for each personnel door. They shall be steel, hot-dipped galvanized after fabrication, and shall comply with the requirements of Division 5, Miscellaneous Metals. They shall comply with the applicable building codes, OSHA standards, State Occupational Safety and Health Plan requirements, and other applicable regulations.

8. The roof shall be of the bolt together panel type, constructed similar to side

walls and shall be a weatherproof deck. The roof shall have a full flashed opening for the exhaust pipe and vent. A gasketed engine exhaust outlet shall be provided as a prevention against leakage into the enclosure. The sidewall, roof and/or floor shall have gasketed openings to accommodate the penetration of support elements.

9. All louver openings shall be full framed and flashed with "U" type drip caps, extending to 4 inches (10 cm) on either side of the opening, with external full length rainhoods.

10. The enclosure shall be designed to withstand wind loading of a minimum of 125 mph (200 km per hour) without damage to the enclosure or roof system. In addition to the wind load, the roof shall be designed for loading of 50 lbs./sq.ft. (2.4 kPa) without buckling or deformation.

11. The enclosure shall be a walk-in type designed to remain structurally intact during normal transport and rigging, with no loss of shape or weathertightness. The enclosure base shall be furnished with "I" beams sized and spaced as required.

12. Louvers shall be fail-safe of the "spring open, motor close" type. The automatic louvered dampers (ALD's) at the intake and discharge louvers shall be quick opening upon signal to start generator. ALD's shall be low leakage type (maximum allowable leakage of 20 cfm/sq.ft. (3.16 cubic meters per hour/square meter) at 4 in. water gauge (1 kPa) differential pressure).

13. Enclosure shall include summer ventilation fan (with necessary louvers) and thermostat, two (2) space heaters complete with thermostat, sized as required to maintain a minimum housing interior temperature of 40 deg F (5 deg C) ; two (2) battery two-head lights, ten (10) interior vaporproof incandescent type lights with associated 3-way toggle switches at enclosure doors, two (2) duplex receptacles, four (4) exterior weatherproof incandescent type lights above door with two (2) weatherproof switches mounted on the exterior of the enclosure, all installed and wired to a local 3 phase, 4 wire, 120/208 volt, 100 ampere panel installation enclosure. Panel shall have a 3P-100A main circuit breaker. All wiring devices and fixtures shall be weatherproof. All generator enclosure devices (lights, heaters, receptacles, etc.) shall be completely wired and piped in rigid galvanized steel conduit to panelboard.

14. The engine-generator set, including radiator, shall be provided with a structural steel base. The base shall have sufficient rigidity for spring type isolators in quantities as required between enclosure floor and generators. Mounting shall incorporate a leveling device, vertical stops, and three layers of neoprene acoustical pad, with each layer separated by a steel plate. The mountings shall be installed directly under the structural steel base and shall be positioned to accept the weight and weight distribution for uniform mounting deflection. Spring isolators shall provide a minimum static deflection of 2 inches (5 cm) and shall be similar to Mason Industries, Inc., Type SLR, or as approved. Neoprene pads shall be similar to Mason Industries, Inc., Type W, or as approved.

15. The entire enclosure shall be mounted on 3/4 inch (19 mm) neoprene waffle pads sized and positioned for 0.11 inch (2.8 mm) deflection at installed loaded conditions. Pads shall be similar to Mason Industries, Inc. Type "Super W", or as approved. The entire assembly shall be capable of withstanding an external force up to 1.0 g without malfunction.

16. The muffler shall be contained within the housing. Exhaust pipe shall extend through the housing and shall be fitted with a rain cap. **[Extend the exhaust pipe a minimum of 10 feet (3 m) above the housing. Include supports as required.]**

C. The generator **[daytank] [fuel tank]** shall be be vented to the outside of the enclosure with a minimum of a 2 inch (5 cm) pipe with appropriate ball plunger type apparatus which will only allow fumes to be released to the atmosphere and not liquids.

D. [**Fuel supply and return shall terminate at the enclosure wall. Supply line shall also be equipped with shutoff valve for unit isolation solenoid valve for unit operation and a "fusible link" Firematic valve for fuel shutoff. The fuel oil return line shall be equipped with a check valve as a prevention from loss of prime as well as a gate valve for unit isolation. Both supply and return piping shall be equipped with stainless steel flexible connections. Fuel oil pipe shall be black seamless steel A53 Schedule 40 with malleable iron fittings.]**

2.16 FINISHES

A. Indoor Enclosures and Components: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

B. Outdoor Enclosures: Polyurethane enamel over corrosion-resistant pretreatment and manufacturer's compatible standard primer.

2.17 SOURCE QUALITY CONTROL

A. Factory Tests: Include Project-specific equipment testing (testing of equipment manufactured specifically for this Project).

B. Project-Specific Equipment Tests: Factory test engine generator set and other system components and accessories before shipment. Test items individually and assembled and connected as a complete system the same as specified in "Field Quality Control" Article below. Record and report test data. Conform to the following:

1. Test Equipment: Use instruments calibrated within the previous 12 months and with accuracy directly traceable to the National Institute of Standards and Technology.

2. Hydrostatic Test: Perform on radiator, heat exchanger, and engine water jacket.

3. Generator Tests: Comply with IEEE 115.

4. Complete-System, Continuous-Operation Test: Include nonstop operation for a minimum of 8 hours, including at least 2 hours each at one-half, three-fourths, and full load. If unit stops during the 8-hour test, repeat the complete test. Record the following minimum data at start and end of each load run, at 15-minute intervals between those times, and at 15-minute intervals during balance of test:

   (a) Fuel consumption.

   (b) Exhaust temperature.

   (c) Jacket water temperature.

   (d) Lubricating oil temperature and pressure.

   (e) Generator load current and voltage, each phase.

   (f) Generator system gross and net output kW.

5. Complete-System Performance Tests: Include the following to demonstrate conformance to specified performance requirements:

   (a) Single-step load pickup.

   (b) Transient and steady-state governing.

   (c) Transient and steady-state voltage performance.

   (d) Safety shutdown devices.

6. Observation of Test: Provide 14 days' advance notice of tests and opportunity for observation of test by Owner's representatives.

7. Report test results within 10 days of completion of test.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.

B. Examine roughing-in of piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install generator set(s), and other components as indicated, in accordance with equipment manufacturers written instructions, and with recognized industry practices, to ensure proper performance in accordance with the specifications.

Comply with applicable NEMA standards pertaining to installation of engine-generator sets and accessories and with NFPA110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. [**Coordinate with the work of other trades including fuel tanks, pumps, piping, ductwork and accessories as necessary to provide a complete operational system.**]

D. Include the installation of control and monitoring panels, battery charger(s), remote annunciator panel, **[day tank(s)]**, batteries and racks and other appurtenances to the extent that such appurtenances are not factory installed and wired. **[Piping between engine and daytank fuel tank complies with Division 15 Section "Fuel Oil Piping."]**

E. Include field interwiring and power supply and control connections for batteries, battery chargers, pumps, heaters, float switches, solenoid valves, damper operators and other miscellaneous items as required in accordance with manufacturers wiring diagrams. Such wiring includes (but is not be limited to):

1. Wiring between battery and engine control panel(s) and battery charger(s).

2. Power supply wiring from an appliance panel to battery charger.

3. Power supply wiring from an appliance panel and control wiring for engine jacket water heater(s).

4. Power supply wiring for fuel pumps and fuel management control panel.

5. Control wiring for fuel pumps, fuel tanks, day tanks, float switches, valves, leak detection system, and other fuel supply system components.

6. Power supply and control wiring for automatic louver damper operators.

7. Emergency stop break glass switch and control wiring run to engine control panel.

8. "Manual start" switch and control wiring to engine control panel.

9. Remote annunciator panel mounted where indicated or where directed, complete with power supply and alarm interwiring to engine control panel.

F. Ground equipment in accordance with Division 16 Section "Grounding and Bonding." .

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 IDENTIFICATION

A. Identify system components according to Division 16 Section "Electrical Identification."

3.4 FIELD QUALITY CONTROL

A. Testing: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

B. Tests: Include the following:

1. Tests recommended by manufacturer.

2. InterNational Electrical Testing Association Tests: Perform each visual and mechanical inspection and electrical and mechanical test stated in InterNational Electrical Testing Association's NETA ATS for emergency engine generator tests. Certify compliance with test parameters.

3. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to these specified herein, including, but not limited to a single step full load pickup test.

4. Testing Load Bank: Building loads may be used for generator testing. Supplement building loads with a resistive load bank as required to load generator to its full rated load for testing. Provide temporary interconnecting cables and connections.

5. Battery Tests: Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions. Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery. Verify acceptance of charge for each element of battery after discharge. Verify measurements are within manufacturer's specifications.

6. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

7. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.

8. Exhaust System Back-Pressure Test: Use a manometer with a scale exceeding 40 inches water gauge (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

9. Exhaust Emissions Test: Conform with applicable government test criteria.

10. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.

11. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

C. Coordinate tests for transfer switches and run them concurrently.

D. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

E. Report results of tests in writing. Record adjustable settings, time delays and other valves and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

F. Test instruments shall be calibrated to National Institute of Standards and Technology (NIST) Standards.

G. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each power wiring termination and each bus connection. Remove all access panels so terminations and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies terminations and connections checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

H. Provide fuel as required for testing, and as required such that fuel tank is full at completion of testing.

3.5 CLEANING

A. Upon completion of installation, inspect system components. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.6 DEMONSTRATION

A. Training: Engage a factory-authorized service representative to demonstrate

adjustment, operation, and maintenance of system and to train Owner's maintenance personnel as specified below.

1. Conduct a minimum of 8 hours of training as specified in Division 1 Section "Contract Closeout."

2. Schedule training with at least 7 days advance notice.

END OF SECTION 16231

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SECTION 16269 - VARIABLE FREQUENCY CONTROLLERS (Installation of)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes installation of solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors. VFC's will be furnished as part of Division 15.

B. Related Sections include the following:

1. Division 16 Section "Basic Electrical Materials and Methods" for general materials and installation methods.

2. Division 16 Section "Enclosed Controllers, (Installation of)" for control wiring.

1.3 DEFINITIONS

A. BMS: Building management system.

B. VFC: Variable frequency controller.

1.4 SUBMITTALS

A. Field Test Reports: Written reports specified in Part 3.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Underwriters Laboratories listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70, as amended by state and local codes.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.7 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.8 EXTRA MATERIALS

A. Spare Fuses: Furnish one spare for every five installed, but not less than one set of three of each type and rating.

PART 2 - PRODUCTS

(NOT APPLICABLE)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. General: Install VFCs in accordance with manufacturer’s written instructions.

B. See Division 16 Section "Basic Electrical Materials and Methods" for additional general installation requirements.

C. Location: Locate controllers as indicated and within site of motors controlled. Where controller is not located within sight of the motor controlled (as defined in the National Electrical Code), provide a nonfusible disconnect switch to serve as the local motor disconnect. Switch includes additional dry contact to lock out operation of VFC when disconnect is open.

D. Mounting: For control equipment at walls, bolt units to wall or mount on light-weight structural steel channels bolted to the wall. For controllers not at walls, provide freestanding racks fabricated of structural steel members and light-weight slotted structural steel channels.

E. Where VFC consists of more than a single cabinet, provide all required interwiring between cabinets.

F. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 16 Section "Fuses."

G. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 16 Section "Electrical Identification."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and terminal cabinets according to Division 16 Section "Enclosed Controllers (Installation of)."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where available.

1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

D. Install control wiring between VFCs and interlock contact in motor disconnect switch and connect to lock-out VFC until switch has been re-closed to permit restart.

E. For each motor automatically and/or manually controlled or monitored by the fire alarm system, include control wiring extensions as specified as part of the fire alarm system to an adjacent FPA addressable module.

3.5 CONNECTIONS

A. Conduit installation requirements are specified in other Division 16 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 16 "Grounding and Bonding."

3.6 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

3. Assist the Division 15 contractor with testing as required.

B. Division 15 trade will engage a factory-authorized service representative to perform startup service.

C. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 16 Sections.

3.7 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.8 CLEANING

A. Clean VFCs internally, on completion of installation, according to manufacturer's written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16269

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SECTION 16289 - TRANSIENT VOLTAGE SUPPRESSION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transient voltage surge suppressors for low-voltage power, control, and communication equipment.

B. Related Sections include the following:

1. Division 16 Section "Panelboards" for factory-installed transient voltage surge suppressors.

2. Division 16 Section "Switchboards" for factory-installed transient voltage surge suppressors.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

B. Product Certificates: Signed by manufacturers of transient voltage suppression devices, certifying that products furnished comply with the following testing and labeling requirements:

1. UL 1283 certification.

2. UL 1449 listing and classification.

C. Field Test Reports: Written reports of tests specified in Part 3 of this Section. Include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Failed test results and corrective action taken to achieve requirements.

D. Maintenance Data: For transient voltage suppression devices to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain suppression devices and accessories through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. IEEE Compliance: Comply with IEEE C62.41, "IEEE Guide for Surge Voltages in Low Voltage AC Power Circuits," and test devices according to IEEE C62.45, "IEEE Guide for Surge Suppressor Testing."

D. NEMA Compliance: Comply with NEMA LS 1, "Low Voltage Surge Protective Devices."

E. UL Compliance: Comply with UL 1283, "Electromagnetic Interference Filters," and UL 1449, "Transient Voltage Surge Suppressors."

F. Comply with NFPA 70, Article 285.

1.5 PROJECT CONDITIONS

A. Placing into Service: Do not energize or connect service entrance equipment, panelboards and data terminals to their sources until the surge protective devices are installed and connected.

B. Service Conditions: Rate surge protective devices for continuous operation under the following conditions, unless otherwise indicated:

1. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.

2. Operating Temperature: 30 to 120 deg F (0 to 50 deg C).

3. Humidity: 0 to 85 percent, noncondensing.

4. Altitude: Less than 20,000 feet (6000 m) above sea level.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cutler-Hammer, Inc.
2. Siemens Energy & Automation.
3. Square D Co.

2.2 SERVICE ENTRANCE SUPPRESSORS

A. Surge Protective Device Description: Non-modular type with the following features and accessories:

1. LED indicator lights for power and protection status.

2. Audible alarm, with silencing switch, to indicate when protection has failed.

3. One set of dry contacts rated at 5 A, 250-V AC, for remote monitoring of protection status.

4. Fuses, rated at 200-kA interrupting capacity.

B. Peak Single-Impulse Surge Current Rating: 240 kA per phase.

C. Connection Means: Permanently wired.

D. Protection modes and UL 1449 clamping voltage for grounded wye circuits with voltages of 480Y/277; 3-phase, 4-wire circuits, are as follows:

1. Line to Neutral: 800 V for 480Y/277.

2. Line to Ground: 800 V for 480Y/277.

3. Neutral to Ground: 800 V for 480Y/277.

2.3 PANELBOARD SUPPRESSORS

A. Surge Protective Device Description: Non-modular type with the following features and accessories:

1. LED indicator lights for power and protection status.

2. Audible alarm, with silencing switch, to indicate when protection has failed.

3. Fuses, rated at 200-kA interrupting capacity.

B. Peak Single-Impulse Surge Current Rating: 120 kA per phase.

C. Protection modes and UL 1449 clamping voltage for grounded wye circuits with voltages of 480Y/277 and 208Y/120; 3-phase, 4-wire circuits, are as follows:

1. Line to Neutral: 800 V for 480Y/277, 400 V for 208Y/120.

2. Line to Ground: 800 V for 480Y/277, 400 V for 208Y/120.

3. Neutral to Ground: 800 V for 480Y/277, 400 V for 208Y/120.

D. Connection Means: Permanently wired.

2.4 PLUG-IN SURGE SUPPRESSORS

A. Description: Non-modular, plug-in suppressors with at least four 15-A, 120-V AC, NEMA WD 6, Configuration 15-15R receptacles, suitable to plug into a NEMA WD 6, Configuration 15-15R receptacle; with the following features and accessories:

1. LED indicator lights for power and protection status.

B. Peak Single-Impulse Surge Current Rating: 13 kA per phase.

C. Protection modes and UL 1449 clamping voltage are as follows:

1. Line to Neutral: 475 V.

2. Line to Ground: 475 V.

3. Neutral to Ground: 475 V.

2.5 CONTROL AND DATA TERMINALS

A. Protectors for copper control, data, antenna, telephone, conductors entering the building from the outside are as recommended by the manufacturer for the type of line being protected.

2.6 ENCLOSURES

A. NEMA 250, with type matching the enclosure of panel or device being protected, unless factory - installed within equipment enclosure.

PART 3 - EXECUTION

3.1 INSTALLATION OF SURGE PROTECTIVE DEVICES

A. Install devices at service entrance on load side of largest service switch, with ground lead bonded to service entrance ground.

B. Install devices for panelboards with conductors between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.

1. Provide multipole, 15-A circuit breaker as a dedicated disconnect for the suppressor, unless otherwise indicated.

3.2 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A.

3.3 FIELD QUALITY CONTROL

A. Testing: Perform the following field quality-control testing:

1. After installing surge protective devices, but before electrical circuitry has been energized, test for compliance with requirements.

2. Complete startup checks according to manufacturer's written instructions.

3. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Section 7.19. Certify compliance with test parameters.

B. Repair or replace malfunctioning units. Retest after repairs or replacements are made.

END OF SECTION 16289

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes individually mounted enclosed switches and circuit breakers used for the following:

1. Service disconnecting means.

2. Feeder and branch-circuit protection.

3. Motor and equipment disconnecting means.

B. Related Sections include the following:

1. Division 16 Section "Wiring Devices" for attachment plugs, receptacles, and toggle switches used for disconnecting means.

2. Division 16 Section "Switchboards" for individually enclosed, fusible switches used as feeder protection.

3. Division 16 Section "Fuses" for fusible devices.

4. Division 16 Section “Selection of Overcurrent Devices” for additional information.

5. Division 16 Section "Enclosed Controllers (Installation of)"

6. Division 16 Section "Variable Frequency Controllers (Installation of)"

1.3 SUBMITTALS

A. Product Data: For each type of switch, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switch and circuit breaker include the following:

1. Enclosure types and details for types other than NEMA 250, Type 1.

2. Current and voltage ratings.

3. Short-circuit current rating.

4. UL listing for series rating of installed devices.

5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Field Test Reports: Written reports specified in Part 3.

D. Maintenance Data: Include the following:

1. Routine maintenance requirements for components.

2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.

3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories.

B. Comply with NEMA AB 1 and NEMA KS 1.

C. Comply with NFPA 70, as amended by state and local codes.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

2. Altitude: Not exceeding 6600 feet (2000 m).

1.6 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Eaton Corp.; Cutler-Hammer Products

2. General Electric Co.; Electrical Distribution & Control Division.

3. Siemens Energy & Automation, Inc.

4. Square D Co.

2.2 ENCLOSED SWITCHES

A. Enclosed, Nonfusible Switch: NEMA KS 1, Type HD, with lockable handle with provisions for two padlocks, and interlocked with cover in closed position. Where used as an in-sight disconnect interposed into the circuit between a Variable Frequency Controller (VFC) and a motor, or used as an in-sight disconnect for a hydraulic elevator, include an auxiliary contact to open the motor control circuit prior to opening of main contacts. Auxiliary contact shall close after the main contacts close. Where used as an in-sight disconnect where six conductors are required between the motor controller and the motor, switch shall be a six pole device regardless of indications on the drawings.

B. Enclosed, Fusible Switch, 800 A and Smaller: NEMA KS 1, Type HD, with clips to accommodate specified fuses, lockable handle with provisions for two padlocks, and interlocked with cover in closed position.

C. Enclosed Fusible Switch, 1200A and Larger: Bolted pressure type, UL 977; operating mechanism shall utilize a rotary-mechanical bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.

D. Service switches on 277/480 volt system shall have shunt trip mechanisms suitable for operation in response to manual activation, or automatic operation in response to ground fault relay.

2.3 ENCLOSED CIRCUIT BREAKERS

A. Refer to Division 16 Section “Selection of Overcurrent Devices” for additional information.

2.4 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R.

2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.

3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.5 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested enclosures before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section.

B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.4 CONNECTIONS

A. Install equipment grounding connections for switches and circuit breakers with ground continuity to main electrical ground bus.

B. Install power wiring. Install wiring between switches and circuit breakers, and control and indication devices.

C. Install control circuit lockout wiring between disconnect switches and VFC’s.

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches and

Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

B. Testing Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.6 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16410

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SECTION 16415 - TRANSFER SWITCHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes transfer switches rated 600 V and less and the following items:

1. Automatic transfer switches.

B. Related Sections include the following:

1. Division 15 Section "Electric-Drive, Horizontal Fire Pumps" for automatic transfer switches furnished with fire pumps.

1.3 SUBMITTALS

A. Product Data: Include dimensioned plans, sections, and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and materials lists.

B. Wiring Diagrams: Details of wiring for transfer switches and differentiating between manufacturer-installed and field-installed wiring. Show both power and control wiring.

C. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for short-circuit closing and withstand ratings applicable to units for Project.

D. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

E. Maintenance Data: For each type of product to include in the maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency meets OSHA criteria for accreditation of testing laboratories, Title 29, Part 1907, or is a full member company of the InterNational Electrical Testing Association.

1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or National Institute for Certification in Engineering Technologies, to supervise on-site testing specified in Part 3.

B. Emergency Service: Manufacturer maintains a service center capable of providing emergency maintenance and repairs at Project site with an 8-hour maximum response time.

C. Source Limitations: Obtain automatic transfer switches from a single manufacturer who assumes responsibility for all components.

D. Listing and Labeling: Provide transfer switches specified in this Section that are listed and labeled for emergency service under UL 1008.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

E. Comply with NFPA 70, as amended by state and local codes.

F. Comply with NFPA 110.

G. Comply with NEMA ICS 1.

H. UL Compliance: Comply with UL 1008, "Automatic Transfer Switches," unless requirements of these Specifications are stricter.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Emerson Electric Co.; Automatic Switch Co. Subsidiary.
2. Russelectric, Inc.
3. Zenith Controls, Inc.

2.2 GENERAL TRANSFER-SWITCH PRODUCT REQUIREMENTS

A. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament loads not exceeding 30 percent of switch ampere rating, unless otherwise noted.

1. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated based on testing according to UL 1008.

B. Where Transfer Switch Includes Internal Protection: Rating of switch and trip unit combination exceeds indicated fault-current value at installation location.

C. Annunciation and Control Interface Components: Devices at transfer switches for communicating with remote annunciators or annunciator and control panels have communications capability matched with the remote device.

D. Solid-State Controls: Repetitive accuracy of all settings is plus or minus 2 percent or better over an operating temperature range of minus 20 degrees C to 70 degrees C.

E. Resistance to Damage by Voltage Transients: Components meet or exceed voltage-surge withstand capability requirements when tested according to ANSI C37.90.1. Components meet or exceed voltage-impulse withstand test of NEMA ICS 1.

F. Neutral Pole: Switch is of the 3-pole type when interposed in a 3-wire feeder, and of the 4-pole type when interposed in a 4-wire feeder, regardless of any other indication to the contrary. Neutral pole is switched simultaneously with phase poles.

G. Neutral Terminal: Ampacity and switch rating of neutral path is equal to the rating of the switch, unless otherwise indicated.

H. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for installation in feeder with oversize neutral is double the nominal rating of the circuit in which the switch is installed.

I. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6; UL 508, unless otherwise indicated.

J. Factory Wiring: Train and bundle factory wiring and label consistent with Shop Drawings, either by color code or by numbered or lettered wire and cable tape markers at terminations.

1. Designated Terminals: Pressure type suitable for types and sizes of field wiring indicated.

2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.

3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.

K. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric motor-operated mechanism, mechanically and electrically interlocked in both directions.

L. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.

1. Limitation: Switches using molded-case switch or insulated-case circuit-breaker components and switches using contactors not designed for continuous-duty repetitive switching between active power sources are not acceptable.

2. Switch Action: Double throw; mechanically held in both directions.

3. Switch Contacts: Silver composition for load current switching. Conventional automatic transfer-switch units rated 225 A and greater have separate arcing contacts.

2.3 AUTOMATIC TRANSFER SWITCH

A. Comply with Level 1 equipment according to NFPA 110.

B. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.

C. Manual Switch Operation: Manually operated under load, with the door closed, and with either or both sources energized. Transfer time is the same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.

D. Signal-before-Transfer and Retransfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source and a second set which operates in advance of transfer to the emergency source. Interval is adjustable from 1 to 30 seconds.

E. Automatic Transfer Switches for Large-Motor Loads: Where supplying elevators or other individual motors 20 HP and larger, operator has a programmed neutral position arranged to provide a midpoint between the 2 working switch positions, with an intentional, time-controlled pause at the midpoint during transfer. The pause is adjustable from 0.5 to 30 seconds minimum and factory set at 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. In lieu thereof include factory-wired, internal, in-phase monitor relay. The relay controls transfer to occur when the 2 sources are synchronized in phase. The relay compares phase relationship and frequency difference between the normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. In-phase transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.

2.4 AUTOMATIC TRANSFER-SWITCH FEATURES

A. Voltage sensing for each phase of normal source. Pickup voltage is adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.

B. Time delay for override of normal-source voltage sensing delays transfer and engine start signals. Adjustable 0 to 6 seconds and factory set at 1 second.

C. Voltage/Frequency Lockout Relay: Prevents premature transfer to an emergency generator set. Pickup voltage is adjustable from 85 to 100 percent of nominal. Factory set to pickup at 90 percent. Pickup frequency is adjustable from 90 to 100 percent of nominal. Factory set to pickup at 95 percent.

D. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes and factory set at 10 minutes. Provides automatic defeat of the delay on loss of voltage or sustained undervoltage of the emergency source, provided normal supply has been restored.

E. Test Switch: Simulates normal-source failure.

F. Switch-Position Pilot Lights: Indicate source to which load is connected.

G. Source-Available Indicating Lights: Supervise sources via the transfer-switch, normal- and emergency-source sensing circuits.

1. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."

2. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

H. Unassigned Auxiliary Contacts: 4 normally open single-pole, double-throw contacts for each switch position, rated 10 A at 240 V, ac.

I. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of the condition of the normal source. A pilot light indicates override status.

J. Engine Starting Contacts: 1 isolated, normally closed and 1 isolated, normally open. Contacts are gold flashed or gold plated and rated 10 A at 32 V, dc minimum.

K. Engine Shutdown Contacts: Time delay adjustable from 0 to 25 minutes; factory set at 5 minutes. Initiates shutdown at remote engine-generator controls after retransfer of load to normal source.

L. Digital Communication Interface: Mod-bus system interface for all control and monitoring functions.

2.5 FINISHES

A. Enclosures: Manufacturer's standard enamel over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

A. Factory Test Components, Assembled Switches, and Associated Equipment: Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Floor Mounting of Switches: Level and anchor unit to floor.

B. Identify components according to Division 16 Section "Electrical Identification."

3.2 WIRING TO REMOTE COMPONENTS

A. For automatic transfer switch(es) include 4 #14 THWN control circuit run in conduit from switch(es) to emergency generator starting and shutdown devices at engine generator control gear. Connect as required.

B. For automatic transfer switch(es) include 2 #14 voltage sensing circuit run in conduit from switch(es) to Building Management System panel to sense "emergency power." Terminate in outlet box with slack conductors (for extension by others) at panel. Connect to voltage sensing contact at ATS.

C. Circuitry extensions from transfer switches as described above include extensions from automatic transfer switches furnished by others as part of fire pump controllers.

D. For automatic transfer switch (es) supplying elevators, include 6 #14 control circuit run in conduit from elevator interface contacts in switch(es) to associated elevator machine room. Terminate in outlet box with slack conductors (for extension by others) adjacent to elevator group controller. Include also 2 #14 run to each hydraulic elevator not supplied through an automatic transfer switch.

3.3 CONNECTIONS

A. Ground equipment as indicated and required by National Electrical Code.

1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Testing: Test transfer-switch products by operating them in all modes. Perform tests recommended by manufacturer under the supervision of manufacturer’s factory-authorized service representative. Correct deficiencies and report results in writing. Record adjustable relay settings.

B. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.

1. Assist in verifying grounding connections and locations and ratings of sensors.

2. Assist in observing reaction of circuit-interrupting devices when simulated fault current is applied at sensors.

C. Coordinate tests with tests of generator plant and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.5 CLEANING

A. After completing equipment installation, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

B. Clean equipment internally, on completion of installation, according to manufacturer's written instructions.

3.6 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain transfer switches and related equipment as specified below:

1. Coordinate this training with that for generator equipment.

2. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment.

3. Schedule training with Owner, through Architect, with at least seven days' advance notice.

4. Provide a minimum of four hours of instruction.

END OF SECTION 16415

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SECTION 16419 - FUSED POWER CIRCUIT DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes bolted-pressure contact switches and high-pressure, butt-type contact switches.

1.3 SUBMITTALS

A. Product Data: For each type of switch specified. Include dimensioned outline drawings and complete description of features of switch and accessory components.

B. Shop Drawings: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Maintenance Data: For switches and accessories to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories.

B. Comply with UL 977.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Bolted-Pressure Contact Switches:

(a) Boltswitch, Inc.

(b) Cutler-Hammer Products; Eaton Corporation.

(c) Pringle Electrical Mfg. Co.

(d) Siemens Energy & Automation, Inc.

(e) Square D/Group Schneider.

2. High-Pressure, Butt-Type Contact Switches:

(a) General Electric Co.

2.2 DEVICE TYPE AND DESCRIPTION

A. Bolted-Pressure Contact Switch: Operating mechanism uses a rotary-mechanical-bolting action to produce and maintain high-clamping pressure on the switch blade after it engages the stationary contacts.

B. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-contact pressure when switch is closed.

C. Main Contact Interrupting Capability: Twelve times the switch current rating, minimum.

D. Operating Mechanism: Manual handle operation to close switch stores energy in mechanism for closing and opening.

1. Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.

2. Mechanical Trip: Operation of mechanical lever or push-button or another device causes switch to open.

E. Enclosure: NEMA 250, Type 1, unless otherwise indicated.

F. Mounting and Anchorage Devices: Comply with manufacturer-certified device descriptions.

G. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.

H. Service-Rated Switches: Labeled for use as service equipment.

I. Ground-Fault Relay: Where required (as specified elsewhere) comply with UL 1053. Self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.

1. Configuration: Integral with fused power circuit device.

2. Tripping Relay: Adjustable pickup current and delay time with inverse- and constant-current characteristics.

3. Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.

4. No-Trip Relay Test: Operation of "no-trip" test control permits ground-fault simulation test without tripping switch.

5. Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).

6. Trip Indicator: Visually indicates ground-fault trip has occurred.

J. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens. Configuration: Integral with fused power circuit device.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mount individual wall-mounting switches with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to floor or equipment base.

3.2 FIELD QUALITY CONTROL

A. Inspect interior of switch enclosures for the following:

1. Mechanical and electrical connections.

2. Switch and relay type and labeling verification.

3. Rating of installed fuses.

4. Proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.

B. Testing: Perform the following field quality-control testing:

1. Test mounting and anchorage devices according to requirements in Division 16 Section "Seismic Controls for Electrical Work."

2. Energize circuits and demonstrate operation. Do not operate switches under load unless approved by Owner and Architect.

(a) Demonstrate switch operation through six opening/closing cycles with circuit unloaded. Test door interlocking device and interlock defeating device.

(b) Electrical Operating Features: Test according to manufacturers' written instructions.

C. Retesting: Correct deficiencies shown by inspections and tests and completely retest work affected by such deficiencies.

D. Report of Inspections and Tests: Written record of results of inspections, tests, and adjustment settings.

END OF SECTION 16419

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SECTION 16420 - ENCLOSED CONTROLLERS (INSTALLATION OF)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the installation of A.C. individually enclosed motor controllers rated 600 V and below. The motor controllers will be furnished as part of Division 15 and Division 13.

B. Related Sections include the following:

1. Division 16 Section “Basic Electrical Materials and Methods” for general materials and installation methods.

2. Division 16 Section “Selection of Overcurrent Devices” for OCD’s and disconnect switches used with motor controllers.

3. Division 15 Section “Enclosed Controllers”.

4. Division 16 Section “Variable Frequency Controllers, Installation of”

1.3 SUBMITTALS

A. Field Test Reports: Written reports specified in Part 3.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70, as amended by state and local codes.

B. The terms "listed" and "labeled" are defined as they are in the National Electrical Code, Article 100.

1.5 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.

C. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

(NOT APPLICABLE)

PART 3 - EXECUTION

3.1 INSTALLATION

A. General: Install independently mounted motor control devices in accordance with manufacturer's written instructions.

B. Location: Locate controllers as indicated and within sight of motors controlled. Where controller is not located within sight of the motor controlled (as defined in the National Electrical Code), provide a nonfusible disconnect switch to serve as the local motor disconnect.

C. Mounting: For control equipment at walls, bolt units to wall or mount on light-weight structural steel channels bolted to the wall. For controllers not at walls, provide freestanding racks fabricated of structural steel members and light-weight slotted structural steel channels.

D. Motor-Controller Fuses: Install fuses in each fusible switch. Conform to requirements of Division 16 Section "Overcurrent Protective Devices."

E. Modify as required the internal control of motors if necessary to accommodate connection of external control wiring in accordance with applicable wiring diagrams.

F. Relay settings: Modify factory settings of adjustable time delay relays in accordance with an approved schedule.

3.2 IDENTIFICATION

A. Identify motor control components and control wiring in accordance with Division 16 Section "Electrical Identification." Where not cover mounted on motor controller, device identification nameplate identify the associated motors.

3.3 CONTROL WIRING

A. Control wiring for HVAC motors will be provided as part of the Building Management System (central mechanical control system) work of Division 15, except for the following wiring which is provided as part of the electrical work (Division 16):

1. For each motor automatically and/or manually controlled or monitored by the fire alarm system, include control wiring extensions as specified as part of the fire alarm system to an adjacent FPA addressable modules.

2. For each motor supplied by a VFC, run 2 #14 from the disconnect switch at the motor to the VFC, and connect so as to de-energize “start circuit” when switch is open. Run with power circuitry or in separate raceway.

B. Control wiring for plumbing/fire protection motors is provided as part of the electrical work. For each such motor, provide wiring and connect to all outlying control devices as directed. Refer to plumbing and fire protection drawings and specifications for quantities and locations.

C. Damper Control Interface: Start command to open associated dampers before the motor is allowed to operate. Input to accept damper limit switch contact closure to allow the motor to operate in hand and auto or remote mode.

D. Safety Control Interface: Input to accept safety device contact closure to stop motor operation in hand and auto or remote mode.

E. Control wiring is accomplished utilizing #14 AWG copper conductor with THWN insulation run in conduit as specified for feeders in Division 16, Section "Raceways."

F. Include any necessary field installed make-up wiring (within motor controller enclosures) as required to incorporate the contained devices and accessories into the control scheme.

3.4 MOTOR CONTROLLER FUSES

A. Motor-Controller Fuses: Install indicated fuses in each fusible switch.

3.5 CONTROL WIRING INSTALLATION

A. Install required control wiring according to Division 16 Section "Wires and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switches and other automatic control devices and accessories within controllers as required to accommodate the control scheme.

1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.

2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

B. Ground equipment.

3.7 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each enclosed controller bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Testing: After installing enclosed switches and circuit breakers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each electrical test and visual and mechanical inspection indicated in NETA ATS, Sections 7.5, 7.6, and 7.16. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Testing Reports: Prepare a written report to record the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

3.8 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 CLEANING

A. Clean enclosed controllers internally, on completion of installation, according to manufacturer’s written instructions. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 16420

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SECTION 16422 - SELECTION OF OVERCURRENT DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification sections apply to this Section.

1.2 SUMMARY

A. This Section includes all overcurrent protective devices (OCPD's) (OCD's) required for the project. It defines the type of OCPD required for each individually mounted device, panelboard, switchboard, switchgear and miscellaneous device required.

B. Related Sections: The following Sections requirements relate to this Section:

1. Division 16, Section "Enclosed Switches and Circuit Breakers."

2. Division 16, Section "Panelboards."

3. Division 16, Section "Switchboards."

4. Division 16, Section "Switchgear."

1.3 SUBMITTALS

A. General: Submit the following according to the Conditions of the Contract and Division 1 Specifications Section.

B. Descriptive data defining how the required short circuit ratings will be met by the equipment furnished under the Related Sections described above. Include UL approval data from manufacturers for "series rated" combinations.

C. In advance of, or in conjunction with, the submission of shop drawings for approval, provide data defining in detail how the required coordination and short circuit current ratings specified elsewhere in these specifications are achieved with the equipment being furnished under the listed Related Sections. The data shall, in narrative or graphic fashion, fully define how the various devices, individually, or in combination, comply with the "fully rated" or "series connected" short circuit current requirements. Include certifications from the manufacturer as to the UL approvals for these ratings for all proposed equipment. Short circuit and coordination study shall include recommended device settings. In particular, demonstrate selective coordination of overcurrent devices used for Emergency Systems and Legally Required Standby Systems.

D. Arc flash study indicating arc flash hazard at each piece of distribution equipment.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 as amended by state and local codes.

B. Listing and Labeling: Products - as described with the Related Sections above - shall be Underwriters Laboratories listed and labeled as defined in NFPA 70 Article 100. Where "series ratings" have been specified, listings attesting to these ratings shall be provided from UL or other nationally recognized testing laboratory.

PART 2 - PRODUCTS

2.1 GENERAL

A. Refer to Related Sections listed hereinbefore for general product requirements.

B. Short circuit current ratings, and the manufacturer's labels attesting to these ratings (based on U.L. listings), will be required for overcurrent protection devices, where they are individually mounted and for the equipment assemblies when they are incorporated in panels, switchboards, switchgear, etc. Such ratings shall be in accordance with the following:-

1. In order to insure that they are at least equal to the available fault current, minimum ratings have been specified herein for the individual overcurrent device types, and in the pertinent sections for panelboards, switchboards, switchgear and other assemblies or devices. Where "series connected ratings" have been specified for circuit breaker type panelboards (see appropriate specification section), these minimum ratings are in general based on the use of upstream devices which have been specifically tested with the circuit breakers, and have been U.L. listed accordingly.

C. All overcurrent protection and switching devices shall be U.L. listed as suitable for the termination of 75 degree C conductors, sized in accordance with their 75 degree C ampacity ratings. Devices shall be specifically identified accordingly and shall bear the designation "60 / 75 degree C" or "75 degree C", regardless of whether incorporated in panelboards, switchboards or other assemblies or whether individually mounted.

2.2 APPLICATION

A. Overcurrent protective devices (OCD'S) shall be provided as described hereinafter.

B. OCD's shall be of the current limiting circuit breaker type (CLCB) except as noted hereinafter.

C. Branch circuit breakers in 277/480 (265/460) volt lighting or appliance panels shall be of the standard molded case type. They shall - in conjunction with upstream CLCB's (either in the mains of these panels or remotely located further upstream) - be "series rated" for 150,000 amps.

D. Main and branch circuit breakers in 120/208 volt panelboards of all types shall be of the standard molded case type.

E. Individually mounted overcurrent protection and switching devices shall be as follows:

1. For use on 277/480 (265/460) volt circuits, they shall be of the CLCB molded case breaker type.

2. For use on 120/208 volt circuits, they shall be of the standard molded case circuit breaker type.

F. Emergency Systems and Legally Required Standby Systems: Overcurrent devices shall be selected such that all overcurrent devices in the distribution system are selectively coordinated.

1. Overcurrent devices for Emergency Systems and Legally Required Standby Systems shall be switch and fuse type. Devices up to and including 800 amperes shall be quick-make, quick-break type switches with cartridge fuses. Devices over 800 amperes shall be bolted pressure type switches with cartridge fuses. This requirement includes all overcurrent devices providing utility service to the transfer switches, providing generator power to the transfer switches, and on the load side of transfer switches - including branch circuit overcurrent protection.

2. Short circuit rating of panelboards and devices shall be as required to provide a fully rated system.

2.3 CURRENT LIMITING CIRCUIT BREAKERS

A. Where intended for mounting in main switchboards, switchgear or as individually mounted service switches they shall be of the 100 percent rated (i.e., capable of carrying 100 percent of their rating continuously), fixed (stationary) mounted and drawout mounted air frame type, with current limiting fuses accessibly mounted in the line side bus connections to each pole of the breakers. They shall be as follows:

1. Their circuit breaker elements shall consist of quick-make quick-break mechanically trip free air immersed circuit breaker mechanisms arranged to operate all poles simultaneously and equipped with an adjustable solid state type overcurrent tripping device, incorporating:-

(a) Short time inverse current characteristic tripping in main breakers.

(b) Instantaneous short circuit tripping except in main breakers.

(c) Long time inverse current characteristic tripping for all breakers.

(d) Ground fault tripping. Refer to Division 16 Section entitled "Main Switchboards "Switchgear" for further information regarding features and functions. Dry contacts which close on ground fault trip shall be provided for monitoring by the BMS.

2. Their breaker contacts shall be complete with arc quenchers in each pole, interpole barriers and latches with mechanical pushbutton trips and position indicators.

3. They shall have shunt trip devices complete with control transformers, "line side" shunt trip control supply connections, and internal factory wiring to accessible terminals as required for the present or future extension of the trip control circuit at a 120 volt control voltage level, to remote normally open external actuating devices.

4. They shall have phase failure protection relay systems arranged to trip them open in response to a sustained voltage in any phase which is lower than 75 percent of the other phase voltages.

5. Sizing of the current limiting fuse for each circuit shall be as selected by the manufacturer as part of the coordination study. Fuses shall be capable of safely interrupting currents of up to 200,000 amperes RMS symmetrical. Fuses shall coordinate with, and back up, the associated circuit breakers so that faults up to the safe capability of the breakers will be interrupted by the breakers, and larger faults will be interrupted by the fuse without damage to the breakers. Where fuses must also be utilized to provide "series connected ratings" of devices in downstream devices as specified hereinafter, they shall be of a size and type that is specifically rated by the circuit breaker manufacturer for this purpose.

B. Current limiting circuit breakers intended for use in power and/or distribution panels, or for use as individually mounted overcurrent protection devices, shall be of the molded case type. In ratings up to the maximum frame size in which they are available from the manufacturer, they shall be of the fuseless type. In larger frame sizes, they shall be of a type which incorporates an integral current limiting fuse in each pole. Current limiting molded case circuit breakers shall be as follows:

1. Their breaker elements shall consist of manually operated, quick-make, quick-break, mechanically trip free operating mechanisms for simultaneous operation of all poles, with contacts, arc interrupters and trip elements for each pole.

2. Their breaker tripping units shall be of the adjustable solid state type incorporating long time delay and instantaneous tripping, or of the "thermal-magnetic" type having bi-metallic elements for time delay overload protection, and magnetic elements for short circuit protection.

3. They shall be of either the fuseless type or of the type which incorporates current limiting fuses. Where required to insure adequate UL approved "series connected" short circuit ratings for downstream lighting or appliance panels, they shall be restricted to the fuseless type only.

4. Where of the fuseless type, they shall incorporate high speed blow-apart current limiting contacts, and shall have a short circuit interrupting capacity of at least 150,000 RMS symmetrical amperes at the specified system voltage.

5. Where they are of the type which incorporates fuses (i.e., in frame sizes larger than 400 amps), they shall be as follows:-

   (a) Their fuses shall be equipped with release buttons arranged to trip open the latches of their circuit breaker elements.

   (b) Each shall have its fuses and breaker elements integrally mounted in a single overall molded phenolic plastic case.

   (c) The fuses shall be capable of safely interrupting fault currents in the order of 200,000 amperes RMS symmetrical. The current limiting fuses shall coordinate with and back up the circuit breakers they are associated with so that all fault overload currents occurring within the safe capability of the breakers shall cause the breakers to open, and all currents occurring beyond the safe capability of the breakers shall cause the fuses to open; the opening of fuses being such as to prevent damage to any circuit breaker components parts.

   (d) Where the fuses must also provide for the "series connected ratings" of downstream devices, they shall be of a size and type for which UL listed "series ratings" have been established for the fuse/downstream circuit breaker combination.

C. Current limiting circuit breakers of the molded case type which serve as main breakers in lighting or appliance panels, or which are located upstream (i.e., at the sending end of feeders or taps) of such panels, shall be of a type which is UL listed in combination with the branch breakers in these panels so as to provided a "series rated" short circuit rating of at least 150,000 amperes for these panels.

D. In lieu of the air frame CLCB's specified hereinbefore for mounting in main switchboards or as individually mounted service switches, stationery molded case circuit breaker sizes may be utilized in frame sizes up to 800 amps. They shall be as follows:

1. They shall be 100 percent rated.

2. They shall be provided with solid state tripping devices, incorporating all of the features and characteristics specified hereinbefore for current limiting air frame circuit breakers.

3. They shall in all other respects comply with the requirements specified for current limiting circuit breakers in power and/or distribution panels.

2.4 STANDARD MOLDED CASE CIRCUIT BREAKERS

A. Standard molded case circuit breakers shall comply with the following:-

1. They shall consist of manually operated quick-make, quick-break mechanically trip free operating mechanisms for simultaneous operation of all poles, with contacts, arc interrupters and trip elements for each pole, all enclosed in molded phenolic plastic cases.

2. Their tripping units shall be of the "thermal magnetic" type having bi-metallic elements for time delay overload protection, and magnetic elements for short circuit protection.

3. Where no frame sizes are indicated their interrupting capacity (in RMS symmetrical amperes) shall not be less than 14,000 amperes for use in 277/480 (265/460) volt lighting and appliance panels, nor less than 10,000 amperes for use in 120/208 volt lighting or appliance panels.

4. Where frame sizes are indicated their interrupting capacity (in RMS symmetrical amperes) shall not be less than 22,000 amperes for 100 amperes and 225 amperes frame circuit breakers, nor less than 42,000 amperes for larger frame sizes.

5. The minimum interrupting capacity in symmetrical RMS amperes of the circuit breakers intended for use in panelboards shall be as noted above. Where necessary in order to provide the UL approved "series connected" short circuit panel ratings in Division 16, Section "Panelboards," breakers with higher interrupting capacities shall be provided as required.

6. They shall be of the "bolted-in" type.

7. Single pole breakers sized 20 amps or less shall be rated for switching duty.

8. Where utilized for circuits supplying HID lighting, they shall be HID rated.

9. They shall be multi-pole circuit breakers, or single-pole circuit breakers with handle ties where serving multi-wire branch circuits in relocatable partitions or systems furniture.

10. They shall be equipped with 5 milliamp sensitivity ground fault interrupting features where so indicated, and/or where they supply 120 volt, 15- and 20-ampere receptacles in bathrooms, kitchens, within 6 feet of sinks, where intended for use by vending machines, and other such code mandated locations and with 30 milliamps sensitivity G.F.I. features where they supply piping tracing cables or snow melting cables or gutter de-icing cables or HWAT cables.

2.5 BOLTED PRESSURE SWITCHES

A. Select bolted pressure type distribution switches in accordance with the following:-

1. They shall have copper current-carrying elements having silver plated contact surfaces.

2. They shall have blade locks to prevent them from opening under short circuit stresses and a mechanism which produces initial contact pressure on the jaws in addition to final bolted pressure when they are closed.

3. They shall be capable of interrupting at least 12 time their rating without damage in accordance with NEMA and UL performance standards.

4. They shall have auxiliary renewable arcing contacts which "make" before and "break" after main current-carrying elements function.

5. They shall be equipped with operating mechanisms which incorporate manual closing and tripping.

6. Where used as service disconnects, they incorporate electrical tripping. Electrical tripping shall incorporate a stored energy mechanism that permits closure only after the opening mechanism has been charged. They shall be complete with control transformers, "line side" trip control supply connections, and internal factory wiring to accessible terminals as required for the present or future extension of the trip control circuit at a 120 volt control voltage level, to remote normally open external actuating devices. The trip circuit shall operate down to 55 percent of nominal voltage.

7. They shall be designed for use with Class "L" fuses.

8. They shall be 100 percent rated when mounted in an enclosure, in accordance with UL test procedures for individual mounting or for incorporation into panelboards or switchboards.

9. They shall be equipped with an Open-Fuse Trip Device arranged to trip switch open if a phase fuse opens.

2.6 QUICK-MAKE, QUICK-BREAK SWITCHES

A. Select quick-make, quick-break type distribution switches in accordance with the following:-

1. They shall equal or exceed the performance required for NEMA type H.D. horsepower rated switches.

2. They shall have arc quenchers and circuit breaker type pressure contacts.

3. Where intended for panelboard or switchboard mounting, they shall be of the "bolted-in" type.

4. They shall be designed for use only with Class "J" fuses up to 600 amps, and "Class L" fuses above 600 amps. Where protecting a branch circuit for emergency systems and legally required standby systems, fuses shall be current limiting type. They shall incorporate factory installed clips designed to insure the use of proper fuses. Coordinate to insure that fuses supplied for the project match these fuse gaps.

5. Switches 400 amperes or larger shall be equipped with an Open-Fuse Trip Device arranged to trip switch open if a phase fuse opens.

2.7 FUSES

A. Select fuses for use in switch and fuse type overcurrent devices in accordance with the following:

1. Regardless of the actual available fault current they shall, at full recovery voltage, be capable of safely interrupting fault currents of 200,000 amperes RMS symmetrical deliverable at the line side of the fuse.

2. They shall be suitable for application to fuse gaps which reject other types of fusing. Coordinate with supplier(s) of all fusible switch units (in panels, switchboards, etc.) for the project to insure that fuse gaps match the specified fuse types.

3. Except as noted hereinafter, in sizes up to 600 amps, they shall be of the Class "J" time delay type, capable of carrying 500 percent of rated current for not less than 10 seconds and UL listed as a "Class J" fuse. Fuses shall be Shawmutt Type "AJT", Bussmann Type "LPJ", or other approved. Approval is contingent on certified test data demonstrating full compliance with the following requirements:-

(a) Fuse shall carry 500 percent of rating for at least 10 seconds.

(b) Fuse shall be suitable for motor feeders when applied at 150 percent of motor full load current.

(c) Fuse selectivity with downstream fuses shall be:-

(1) 2:1 with "J" time delay

(2) 3:1 with "RK-5" time delay

(3) 2:1 with "RK-1" time delay

4. Where intended for use in motor starters (individual, or in motor control centers) they shall be of the dual element time delay type, UL listed as "Class RK-5", and capable of carrying 500 percent of rating for at least 10 seconds. Utilize "Class RK-1" time delay fuses where required to insure coordination with upstream fuses.

5. Where protecting a branch circuit fuses shall be current limiting type.

6. Except as noted hereinafter, in sizes over 600 amps, they shall be of the

current limiting type, UL listed as "Class L".

7. Where protecting a feeder or tap supplying a single large motor or transformer, fuses in the range of 800 to 2000 amps shall have special "Class L" time delay characteristics equal to Shawmutt Type "A4BT" or Bussmann Type "KRP-C" fuses.

2.8 GROUND FAULT TRIPPING

A. Provide ground fault tripping for each individually mounted service switch over 800 amps and for each main switchboard device and each switchgear device.

2.9 ELEVATOR POWER/DISTRIBUTION PANELS

A. Branch units in power/distribution panels supplying elevators shall be of the quick-make, quick-break distribution switch type with time delay fuses.

1. Where serving as the in-sight disconnect for a hydraulic elevator, they shall incorporate an auxiliary dry contact.

PART 3 - EXECUTION

3.1 GENERAL

A. Comply with the requirements of Division 16 Sections "Enclosed Switches and Circuit Breakers," "Fuses," "Panelboards," "Switchboards" and "Switchgear".

B. Submit recommended settings for all adjustable or interchangeable overcurrent and ground fault tripping devices. Include a complete short circuit and coordination study to demonstrate that the recommended device settings will provide a completely coordinated system based on the available fault currents, except where "full" coordination is not possible due to the series rating of devices and/or where instantaneous trip devices are in series. Full coordination of all devices used for Emergency Systems and Legally Required Standby Systems is required. Include all work required in the field to verify that factory settings are as recommended, and to field set device whose settings are not as recommended.

END OF SECTION 16422

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SECTION 16424 - FEEDERS AND BRANCH CIRCUITRY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes basic requirements for the installation of light and power feeders and circuitry run at less than 600 volts.

B. Related Sections: The following sections contain requirements that relate to this Section:

1. Division 16, Section "Raceways and Boxes."

2. Division 16, Section "Conductors and Cables."

3. Division 16, Section "Panelboards."

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Circuited up "as-built" drawings and panel directories as called for in the Division 16 related sections.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70, as amended by state and local codes.

PART 2 - PRODUCTS

2.1 GENERAL

A. Products shall be as specified in the Division 16 related sections.

PART 3 - EXECUTION

3.1 INSTALLATION OF FEEDERS

A. Feeder connections shall be in the phase rotation which establishes proper operation for all equipment supplied.

B. Feeders consisting of multiple cables and raceways shall be arranged such that each raceway of the feeder contains one cable for each phase leg (and one neutral cable if any).

C. Each individual tap off a feeder which consists of multiple cables per phase (and neutral if any) shall be arranged so that all of the cables of a phase leg (and neutral if any) of the feeder are connected to the corresponding phase leg (and neutral if any) of the individual tap.

D. Indications of conductor sizing for three phase and three phase/four wire feeders shall, unless otherwise noted on the drawings, be understood as follows:

1. (3) equally sized conductors represents a three phase feeder.

2. (4) equally sized conductors represents a three phase/4 wire feeder with 100% neutral.

3. (3) equally sized conductors plus (1) smaller conductor represents a three phase/three wire feeder plus ground wire.

4. (4) equally sized conductors plus (1) smaller conductor represents a three phase/four wire feeder plus ground wire).

5. (3) equally sized conductors plus (1) larger conductor or (2) equally sized conductors represents a three phase/4 wire feeder with neutral oversized to accommodate "harmonic-rich loads."

6. (3) equally sized conductors plus (1) larger conductor or (2) equally sized conductors and one smaller conductor represents a three phase/four wire feeder with neutral oversized to accommodate "harmonic-rich" loads plus a ground wire.

3.2 INSTALLATION OF LIGHTING AND APPLIANCE BRANCH CIRCUITRY

A. Circuitry indicated without sizing shall be understood to be lighting and appliance branch circuitry protected at 20 amps or less.

B. Conform all lighting and appliance branch circuitry (regardless of whether protected above or below 20 amps) to the following:-

1. Except as noted below, circuitry shall be multi-wire utilizing common neutrals arranged so that no neutral conductor acts as a common wire for more than one circuit conductor connected to the same phase leg of the supply system.

(a) Common neutrals shall not be utilized for circuitry runs emanating from panel branches having ground fault interrupting features regardless of any indication to the contrary on the floor plans.

(b) Common neutrals shall not be utilized for circuitry runs containing more than (6) 120 volt receptacle circuits within a single raceway (conduit, underfloor duct).

2. Conductors used as common neutrals for multiple (2 or 3) 120 volt branch

circuits protected at 20 amps or less shall be #10 AWG where such circuits supply receptacles which are dedicated to - or may be utilized for - "harmonic-rich" loads such as personal computers, computer terminals, word processors, printers and the like. Accordingly, common neutrals supplying receptacles shall be understood to be #10 AWG under the following conditions:

(a) Wherever so indicated (by note or otherwise) on the drawings.

(b) Throughout all office areas, computer rooms or other data processing spaces and laboratories.

3. Branch circuitry supplying relay controlled lighting fixtures shall be understood to include all necessary interconnections between the control panels containing the relays and the associated lighting or appliance panels.

4. Under no condition shall any local switch break a neutral conductor.

5. At any location where lighting and appliance branch circuitry is extended from a flush mounted panelboard to a suspended ceiling immediately above, at least four 1-inch empty conduits shall be included (in addition to those required for active circuitry) to permit future wiring escape from the panel-board. The empty conduits shall extend up from the panel and shall terminate in a threaded conduit cap immediately after turning out into the hung ceiling space.

6. Raceway sizes shall conform to standard maximum permissible occupancy requirements except where these are exceeded by other requirements specified elsewhere.

7. Two and three pole branches in panels shall be used respectively for individual single phase load items connected line to line and individual three phase load items. Where circuitry indications require the use of 2-pole and/or 3-pole branch breakers which have not been scheduled, provide in the panelboards the required multi-pole breakers in lieu of the equivalent number of single pole branch breakers. Required quantities of single, two and three pole branch breakers shall be confirmed prior to ordering panels.

C. Conform lighting and appliance branch circuitry, indicated as being protected at 20 amps or less, to the following:-

1. 120 volt circuitry shall be supplied from 20 amp panel branches except as indicated otherwise.

2. 277 (265) volt circuitry shall be supplied from 20 amp panel branches except as indicated otherwise.

3. Except as specified below, minimum conductor size shall be #12 AWG.

4. Common neutrals shall not be utilized for circuitry runs containing more than (6) 120 volt receptacle circuits within a single raceway (conduit, cellular deck, underfloor duct]) except as noted below.

5. For circuitry run in underfloor raceway systems (cellular deck, underfloor duct), comply with the following:

   (a) Utilize #10 AWG phase leg conductors and #8 AWG neutral conductors for runs contained in branch cells or ducts (i.e., cells or ducts intended for the direct supplying of receptacles or other outlets from after-set inserts or pre-set inserts mounted on them).

   (b) Utilize #8 AWG conductors for home run circuitry contained in main runs (i.e., trench headers, junction headers or header ducts).

   (c) Common neutrals shall be utilized for all circuitry contained in main runs and branch runs. Neutral conductors shall be tapped and reduced in insert outlet boxes to #10 or #12 AWG for direct connection to receptacles.

6. Conductors for 120 volt circuitry extending in excess of 75 feet, from the point of supply, to the first outlet shall be #10 AWG (minimum) copper to the first outlet. Increase beyond #10 AWG if required for compliance with code-mandated voltage drop restrictions.

7. Conductors for 277 (265) volt circuitry extending in excess of 150 feet, from the point of supply, to the first outlet shall be #10 AWG (minimum) copper to the first outlet. Increase beyond #10 AWG if required for compliance with code-mandated voltage drop restrictions.

8. Conductors used in runs consisting of more than six wires (exclusive of grounding conductors) in a single raceway shall be #10 AWG copper minimum. Increase beyond #10 AWG as required to comply with code-mandated derating factors, and as specified hereinbefore.

9. Circuits supplying receptacles which are not of the ground fault circuit interrupting type, and are located as noted below, shall be connected to panel branches that are equipped with ground fault interrupting features:

   (a) Receptacles located in bathrooms. Bathrooms shall be defined as spaces containing a basin plus a toilet, tub or shower.

   (b) Receptacles located within 6 feet of any sink and intended to serve counter top surfaces.

   (c) Receptacles in commercial and institutional kitchens.

   (d) All receptacles mounted on building exterior surfaces.

   (e) All receptacles mounted in garages.

(f) All receptacles mounted in elevator machine rooms, machinery spaces and pits.

10. Circuits supplying pipe tracing cable, snow melting cable, gutter melting cable and HWAT cable shall be connected to panel branches equipped with 30 ma interrupting features for equipment protection.

D. Where circuitry has not been delineated for lighting fixtures, receptacles, switches and miscellaneous items intended for protection at 20 amps, such items shall be provided with circuitry conforming to the requirements listed below. Prior to installation of circuitry, submit for review floor plans showing circuit numbers, home runs, and interconnecting circuitry for all such items.

1. When circuiting up recessed ceiling lighting fixtures, connect fixtures on the basis of more than one fixture to a single outlet box, in an approved manner, as required to insure that circuits will not be unnecessarily lightly loaded due to mandated, restrictions on the maximum number of outlets per circuit. Except with special permission, unnecessarily light loading shall be understood to mean, less than 1000 volt amps (VA) on a 120 volt circuit and less than 3200 VA on a 277 volt circuit.

2. The total load on a circuit shall be computed by ascribing volt-amps to individual items on the basis of the following:-

ITEM	VOLT-AMPS (VA)
Any lighting fixture.	Input volt-amps as per lighting fixture schedule.
Any outlet with no specific wattage or circuiting instruction indicated.	180 volt amperes
Any outlet (other than for resistance heating) with wattage indicated.	1.15 x Indicated wattage
Any resistance heating outlet with wattage indicated.	1.0 x Indicated wattage
Any fractional HP motor with HP indicated.	2500 x Indicated HP
Any outlet with amps indicated.	120 x Indicated amps

3. Not more than 1300 total VA shall be applied to any 15 amp, 120 volt panel branch circuit nor more than 1450 VA to any 20 amp, 120 volt branch circuit. Not more than 4000 VA shall be applied to any 277 (265) panel branch circuit.

4. A separate 20 amp panel branch circuit supplying no other outlets shall be used for each outlet indicated as an "individual appliance circuit" or "heavy duty" outlet.

5. Lighting fixture shall be connected to 20 amp panel branch circuits. Solidly connected equipment less than 1300 VA shall be connected to 15 amp panel branch circuits except as indicated or noted herein.

6. Lighting fixtures and receptacles shall not be connected to the same branch circuit.

7. Any installed lighting and appliance branch circuitry, found (as a result of unnecessarily light loading of conductors) to make excessive use of panel branches, shall be rearranged.

8. Circuits shall be balanced on phases at their supply point as evenly as possible.

9. The final arrangement of lighting and appliance branch circuitry shall be fully delineated on the record, or "as-built" drawings called for elsewhere.

END OF SECTION 16424

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SECTION 16427 - METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes provisions for the accommodation of utility company metering equipment.

B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:

1. "Raceways and Boxes."

2. "Conductors and Cables."

3. "Submetering" .

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product data for each product and component specified.

2. Shop drawings of utility company metering provisions with indication of approval by utility company.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide components that are Underwriters Laboratories listed and labeled.

1. The terms "listed" and "labeled": As defined in the National Electrical Code, Article 100.

B. Electrical Component Standard: Components and installation shall comply with NFPA 70 .

1.5 GENERAL

A. All electricity delivered to the project will be utility company metered through a main "house" metering installation. Electricity consumed by each tenant will be submetered by the airport. Submetering system shall be E-Mon or approved equal.

B. Provide meter pans and/or backboards and current transformers per utility company requirements.

C. Provide instrument wiring per utility company requirements.

D. Provide "house" meter totalizing impulse wiring systems per utility company requirements.

E. Install current trsnsformers furnished by the utility company.

F. Meters will be furnished and installed by the utility company.

G. All work for the metering installation shall be provided in accordance with instructions issued by the utility company.

PART 2 - PRODUCTS

2.1 GENERAL

A. Furnish in accordance with the applicable requirements of Division 16 Sections "Wires and Cables" and "Raceways, Boxes and Cabinets."

PART 3 - EXECUTION

3.1 GENERAL

A. Install in accordance with the applicable requirements of Division 16 Sections “Conductors and Cables" and "Raceways and Boxes."

END OF SECTION 16427

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SECTION 16428 - SUBMETERING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes an electronic submetering system using power line carrier (PLC) signal transmission.

1.3 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each component specified, including detailed manufacturer's specifications. Include data on features, ratings, and performance. Include dimensioned views of components and enclosures.

C. Wiring diagrams detailing internal and interconnecting wiring.

D. Qualification data for firms and persons specified in the "Quality Assurance" Article. Describe capabilities and experience, and provide references when requested.

E. Field test reports for tests specified in Part 3.

F. Maintenance data for products to include in the operation and maintenance manual specified in Division 1. Include the following:

1. Detailed operating instructions covering operation under both normal and abnormal conditions.

2. Routine maintenance requirements for system components.

3. Lists of spare parts and replacement components recommended to be stored at the site for ready access.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced Installer who is an authorized representative of the system manufacturer to supervise installation of the system.

B. Manufacturer Qualifications: Engage firms experienced in manufacturing systems and equipment similar to those indicated for this Project and that have a record of successful in-service performance.

C. Service Center: Select a system manufacturer who maintains a service center capable of providing training, parts, and emergency maintenance and repairs at the Project site with a 24-hour maximum response time.

D. Comply with NFPA 70.

E. Listing and Labeling: Provide Underwriters Laboratories listed and labeled items for system components of types covered by listing or labeling services.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

1.5 WARRANTY

A. Special Warranty: Submit a written warranty signed by the manufacturer and Installer agreeing to correct system deficiencies and replace components that fail in materials or workmanship within the specified warranty period when installed and used according to the manufacturer's written instructions. This warranty shall be in addition to, and not limiting, other rights the Owner may have under other provisions of the Contract Documents.

B. Special Warranty Period: 3 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. E-Mon

2.2 SYSTEM DESCRIPTION

A. The electronic submetering system shall utilize power line carrier (PLC) distribution of signals and shall consist of the following:

1. Central data collection equipment.

2. Outlying submetering modules (i.e., "submeters").

3. Current transformers.

4. 9600 baud (minimum) Hayes - compatible modem.

5. On-site billing equipment. (Including any necessary software).

6. Interwiring as required.

B. The outlying submetering modules shall each consist of a microprocessor based electronic metr, a carrier current communications section for two-way distribution of data over power lines, and a power supply. The modules shall each function in conjunction with current transformers and voltage supply connections as follows:

1. Meters and associated current transformers shall be provided for individual tenants as indicated on plans.

2. Each submeter shall monitor current voltage and power so as to enable computing of kilowatt-hours (KWH) consumption and kilowatt (KW) integrated demand (over 15 or 30 minute period to match local utility company practice). Consumption and demand shall be displayed on command (or continuously) at the submeter.

3. The modules shall have a non-volatile memory so that information will be retained without use of batteries in the event of voltage disturbances or power outages.

4. The modules shall be capable of measuring 120/208 volt single phase, 3 wire, 120/208 volt 3 phase, 4 wire and 277/480 volt 3 phase, 4 wire electrical services, and shall be accurate within 2 percent.

5. The modules shall transmit data to the central equipment to enable the storage of KWH consumption and 15 or 30 minute integrated KW demand on a time-of-day basis, with the time frame divided into two to four intervals per day in accordance with local utility practice. It shall be possible to randomly combine the data from multiple outlying meter modules so as to read totalized KWH consumption and coincident integrated demand KW.

6. Include equipment, wiring and software to permit individual or coincident demands to be reported at the time that the building Utility Company master meter peaks each month. Include wiring to the Utility Company meter, as well as the cost of any charges from the Utility Company for interface equipment necessary to monitor the Utility Company demand meter.

7. Data transmission shall be over building power supply wires. Dedicated wiring shall not be required between meter modules and the central equipment.

C. The central equipment shall include all items necessary to receive data from outlying submeters to analyze and store data as it is received, to query each outlying submeter to verify proper operation, to transmit data on demand for readout of consumption and demand for any submeter unit. The central equipment shall also include all items as necessary to transmit data via modem, utilizing telephone lines, to an off-site facility for billing and/or diagnostic purposes. It shall also be able to transmit data to on-site billing equipment if provided.

D. Provide on-site billing equipment including but not limited to microcomputer, software, printer and peripheral printer as required to permit the Owner to prepare monthly bills for outlying submeter.

PART 3 - EXECUTION

3.1 GENERAL

A. The system shall generally utilize building power circuitry for the transmission of data to and from the submetering modules. To the extent that wiring is required for data transmission and for power live connections, it shall be included and shall comply with Division 16 Sections "Wires and Cables" and "Raceway, Boxes and Cabinets."

B. The system and all its components must receive the approval of all agencies having jurisdiction, prior to installation of any equipment or wiring.

C. The system supplier must guarantee his ability to provide off-site diagnostic analysis of the system via telephone lines, as well as his ability to provide off-site preparation of bills in the required format required by Owner. Include one year's free diagnostic service (including on-site repairs and adjustments) and preparation of bills.

D. Submit a separate price for service, repairs and off-site billing after the first year.

3.2 IDENTIFICATION

A. Identify system components, wiring, and cabling, according to Division 16 Section "Electrical Identification."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly and components connection and the pretesting, testing, and adjusting of the system.

B. Inspection: Verify that components and wiring are properly installed, connected, and labeled and that interconnecting wires and terminals are identified.

C. Pretesting: Pretest all components, wiring, and functions to verify they conform to specified requirements. Replace malfunctioning or damaged items with new items. Retest until satisfactory performance and conditions are achieved.

D. Operational Acceptance Tests: Perform operational system tests to verify system conforms to Specifications. Include all modes of system operation.

3.4 DEMONSTRATION

A. Training: Arrange and pay for the services of a factory-authorized service representative to demonstrate operation, and maintenance of the system and to train Owner's personnel.

1. Demonstrate programming of the central equipment.

2. Demonstrate on-site preparation of bills.

B. Conduct a minimum of 6 hours' training.

C. Schedule demonstration, training, and adjustment with Owner with at least 7 days' advance notice.

END OF SECTION 16428

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SECTION 16430 - SWITCHGEAR

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes metal-enclosed, low-voltage, power circuit-breaker switchgear rated 1000 V and less for use in AC systems.

1.3 SUBMITTALS

A. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each type of switchgear and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

a. Enclosure types and details.

b. Nameplate legends.

c. Bus configuration with size and number of conductors in each bus run, including phase, neutral, and ground conductors of main and branch buses.

d. Current rating of buses.

e. Short-time and short-circuit current rating of switchgear assembly.

f. Mimic-bus diagram.

g. Utility company's metering provisions with indication of approval by utility company.

h. UL listing for series rating of installed devices.

i. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Diagram power, signal, and control wiring and differentiate between manufacturer-installed and field-installed wiring.

C. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

E. Manufacturer's field service report.

F. Maintenance Data: For switchgear and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Closeout Procedures," include the following:

1. Routine maintenance requirements for switchgear and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain switchgear through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories.

C. Comply with NFPA 70, as amended by state and local codes.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.

B. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

1.6 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.

2. Indicate method of providing temporary utilities.

3. Do not proceed with utility interruptions without Architect's written permission.

1.7 COORDINATION

A. Coordinate layout and installation of switchgear and components with other construction that penetrates ceilings or is supported by them, including conduit, piping, equipment, and adjacent surfaces. Maintain required clearances for workspace and equipment access doors and panels.

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Six of each type and rating used. Include spares for potential transformer fuses, control power fuses, and fuses and fusible devices for fused circuit breakers.

2. Indicating Lights: Six of each type installed.

3. Touchup Paint: Three containers of paint matching enclosure finish, each 0.5 pint (250 mL).

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. ABB Power T&D Co., Inc.; Distribution Systems Div.

2. Cutler-Hammer, Inc.

3. GE Electrical Distribution & Control.

4. Siemens Energy & Automation, Inc.

5. Square D Co./Groupe Schneider NA.

2.2 RATINGS

A. Nominal System Voltage: 480/277 V , 4 wire, 60 Hz.

B. Main-Bus Continuous: As indicated on the drawings.

C. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

2.3 FABRICATION

A. Factory assembled and tested and complying with IEEE C37.20.1.

B. Indoor Enclosure Material: Steel.

C. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.

D. Section barriers between main circuit-breaker compartments shall be extended to rear of section.

E. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main circuit breaker.

F. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.

G. Fabricate enclosure with removable, hinged, rear cover panels, secured by captive thumbscrews, to allow access to rear interior of switchgear.

H. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:

1. Utility metering compartment that complies with utility company requirements.

2. Bus transition sections.

3. Incoming-line pull sections.

4. Hinged front panels for access to metering, accessory, and blank compartments.

5. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.

a. Set pull box back from front to clear circuit-breaker lifting mechanism.

b. Bottom: Insulating, fire-resistant material with separate holes for

cable drops into switchgear.

c. Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.

I. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.

1. Main Phase Bus: Uniform capacity the entire length of assembly.

2. Neutral Bus: 100 percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.

3. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.

4. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.

5. Contact Surfaces of Buses: Silver plated.

6. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

7. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size 1/4 by 2 inches (6 by 50 mm).

8. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents

9. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.

10. Neutral Disconnect Link: Bolted, uninsulated, 1/4-by-2-inch (6-by-50-mm) copper bus, arranged to connect neutral bus to ground bus.

11. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.

2.4 COMPONENTS

A. Instrument Transformers: Comply with IEEE C57.13.

1. Potential Transformers: Secondary voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.

2. Current Transformers: Ratios, burden and accuracy class suitable for connected relays, meters, and instruments.

3. Zero-Sequence, Window-Type Current Transformers: Located and

connected to provide selective ground fault relaying.

B. Analog Instruments: Rectangular, 4-1/2-inch (115-mm) square, 1 percent accuracy, semiflush, with antiparallax 250-degree scale and external zero adjustment, complying with ANSI C39.1.

1. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.

2. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.

3. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.

4. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.

5. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.

a. Operation: Meter counts and records a succession of pulses entering two channels.

b. Housing: Drawout, back-connected case arranged for semiflush mounting.

6. Locate ammeter and selector switch and recording demand meter on circuit breaker compartment door for each service switch and feeders indicated on the drawings.

C. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.

D. Surge Arresters: Distribution class, metal-oxide-varistor type. UL listed for the purpose. One surge arrester for each ungrounded conductor.

1. Install in cable termination compartments and connect in each phase of incoming circuit ahead of any disconnecting device.

2. Coordinate rating with circuit voltage.

3. Comply with IEEE C62.11 and NEMA LA 1.

4. Comply with NFPA 70, Article 280 “Surge Arresters”.

5. Comply with NFPA 780, “Standard for the Installation of Lightning Protection Systems”.

6. Comply with UL 96A.

E. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.

F. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including

instruments and instrument transformers.

G. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:

1. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.

2. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.

a. Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.

b. Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.

3. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.

H. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:

1. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.

2. Conductors sized according to NFPA 70 for the duty required.

2.5 CIRCUIT BREAKERS

A. Description: Comply with IEEE C37.13.

B. Refer to Division 16 Section "Selection of Overcurrent Devices" for additional requirements.

C. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.

D. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:

1. Normal Closing Speed: Independent of both control and operator.

2. Slow Closing Speed: Optional with operator for inspection and adjustment.

3. Stored-Energy Mechanism: Electrically charged, with optional manual charging.

4. Operation counter.

E. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:

1. Functions: Long-time-delay, short-time-delay (main and tie breakers only), and instantaneous-trip functions (omit from main and tie breakers), independent of each other in both action and adjustment.

2. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.

3. Field-adjustable, time-current characteristics.

4. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.

5. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."

6. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I-squared-t operation.

7. Pickup Points: Five minimum, for instantaneous-trip functions.

8. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:

    a. Four-wire circuit or system.

9. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.

F. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.

G. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:

1. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.

2. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed, unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:

    a. Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.

b. Disconnected Position: Primary and secondary devices and ground contact disengaged.

H. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.

I. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.

J. Operating Handle: One for each circuit breaker capable of manual operation.

K. Electric Close Button: One for each electrically operated circuit breaker.

L. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.

M. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.

N. Undervoltage Trip Devices: Adjustable time-delay and pickup voltage.

O. Shunt-Trip Devices: Where indicated.

P. Fused Circuit Breakers: Circuit breaker and fuse combinations complying with requirements for circuit breakers and trip devices and with the following:

1. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.

2. Circuit Breakers with Frame Size 1600 A and Smaller: Fuses on line side of associated circuit breaker, on a common drawout mounting, arranged so fuses are accessible only when circuit breaker is in disconnected position.

3. Circuit Breakers with Frame Sizes More Than 1600 A: Fuses and circuit breakers may be installed in separate compartments on separate drawout mountings. Fuse drawout element is interlocked with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in open position.

4. Open-Fuse Trip Device: Positive means of tripping and holding circuit breaker in open position when a fuse opens. Open-fuse status is indicated at front of circuit breaker or fuse drawout element.

Q. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

2.6 ACCESSORIES

A. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.

1. Racking handle to manually move circuit breaker between connected and disconnected positions.

2. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.

3. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.

B. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.

C. Spare-Fuse Cabinet: Identified and compartmented steel box, or cabinet with lockable door.

D. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

2.7 IDENTIFICATION

A. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.

1. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.

2. Medium: Painted graphics, as selected by Architect.

3. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.

B. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:

1. Frame size of each circuit breaker.

2. Trip rating for each circuit breaker.

3. Conduit and wire size for each feeder.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive switchgear for compliance with installation tolerances and other conditions affecting performance.

1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Anchor switchgear assembly to 4-inch (100-mm), channel-iron floor and attach by bolting.

1. Sills: Select to suit switchgear; level and grout flush into floor or concrete base.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Bus Diagram and Instructions: Frame and mount under clear acrylic plastic on the front of switchgear.

C. Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.

3.4 CONNECTIONS

A. Install equipment grounding conductors for switchgear with ground continuity to main electrical ground bus.

B. Tighten bus joints, electrical connectors, and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Manufacturer’s Field Services: Engage a factory-authorized service representative to inspect field-assembled components, installation, and connection of switchgear, and to pretest and adjust switchgear components. Report results in writing.

C. Testing: After installing switchgear and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Perform each electrical test and visual and mechanical inspection indicated in NETA ATS. Certify compliance with test parameters.

a. Switchgear: Perform tests and inspections stated in NETA ATS, Section 7.1.

b. Circuit Breakers: Perform tests and inspections stated in NETA ATS, Section 7.6.

c. Protective Relays: Perform tests and inspections stated in NETA ATS, Section 7.9.

d. Instrument Transformers: Perform tests and inspections stated in NETA ATS, Section 7.10.

e. Metering and Instrumentation: Perform tests and inspections stated in NETA ATS, Section 7.11.

f. Ground-Fault Systems: Perform tests and inspections stated in NETA ATS, Section 7.14.

g. Battery Systems: Perform tests and inspections stated in NETA ATS, Section 7.18.

h. Surge Arresters: Perform tests and inspections stated in NETA ATS, Section 7.19.

i. Capacitors: Perform tests and inspections stated in NETA ATS, Section 7.20.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.

1. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Substantial Completion.

2. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

3. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

A. Set field-adjustable, protective-relay trip characteristics.

3.7 CLEANING

A. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

3.9 STARTUP SERVICES

A. Engage a factory-authorized service representative to perform startup service.

B. Verify that switchgear is installed and connected according to the Contract Documents.

C. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 16 Sections.

D. Complete installation and startup checks according to manufacturer's written instructions.

3.10 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchgear.

1. Train Owner's maintenance personnel on procedures and schedules for energizing and de-energizing, troubleshooting, servicing, and maintaining equipment and schedules.

2. Review data in maintenance manuals. Refer to Division 1 Section "Closeout Procedures."

3. Review data in maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."

4. Schedule training with Owner, through Architect, with at least seven days' advance notice.

END OF SECTION 16430

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SECTION 16441 - SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes service and distribution switchboards rated 600 V or less.

B. Related Sections include the following:

1. Division 16 Section "Enclosed Switches and Circuit Breakers" for overcurrent protective devices used in switchboards.

2. Division 16 Section "Fuses."

3. Division 16 Section "Selection of Overcurrent Devices" for overcurrent protection program.

4. Division 16 Section “Transient Voltage Suppression” for surge suppressors.

1.3 SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:

(a) Enclosure types and details for types other than NEMA 250, Type 1.
(b) Bus configuration, current, and voltage ratings.
(c) Short-circuit current rating of switchboards and overcurrent protective devices.
(d) Descriptive documentation of optional barriers specified for electrical insulation and isolation.
(e) Mimic-bus diagram.
(f) UL listing for series rating of installed devices.
(g) Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Field Quality Control Test Reports: Including the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Manufacturer's field service report.

E. Maintenance Data: For switchboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Contract Closeout," include the following:

1. Routine maintenance requirements for switchboards and all installed components.

2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

3. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain switchboards through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories.

C. Comply with NEMA PB 2, “Deadfront Distribution Switchboards”.

D. Comply with NFPA 70, as amended by state and local codes.

E. Product Selection for Restricted Space: Drawings indicate space available for switchboards. Comply with code required or indicated clearances between switchboards and adjacent surfaces and other items and with space restrictions, including space indicated for future equipment.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver in sections of lengths that can be moved past obstructions in delivery path.

B. Store indoors in clean dry space with uniform temperature to prevent condensation. Protect from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subjected to weather, cover switchboards to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchboards; install electric heating (250-W per section) to prevent condensation.

D. Handle switchboards according to NEMA PB 2.1 and NECA 400.

1.6 PROJECT CONDITIONS

A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.

B. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 104 deg F (40 deg. C).

2. Altitude: Not exceeding 6600 feet (2000 m).

C. Service Conditions: NEMA PB2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.

2. Altitude not exceeding 6600 feet (2000 m).

D. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify Architect not less than seven days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions.

2. Indicate method of providing temporary utilities.

3. Do not proceed with interruptions of electric service without Architect's written authorizations.

1.7 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.8 EXTRA MATERIALS

A. Spare Fuses: Six spares of each type and rating of fuse and fusible devices used. Include spares for:

1. Potential transformer fuses.

2. Control power fuses.

3. Fuses and fusible devices for fused type current limiting circuit breakers.

4. Fuses for fusible switches.

B. Spare Indicating Lights: Six of each type installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Eaton Corp; Cutler Hammer Products

2. General Electric Co.; Electrical Distribution and Control Division.

3. Siemens Energy & Automation, Inc.

4. Square D Co.

2.2 MANUFACTURED UNITS

A. NEMA Class 1 type switchboard:

1. Main Devices: Fixed individually mounted.

2. Branch Devices: Panel and fixed individually

3. Nominal System Voltage: 480Y/277V.

B. Factory tests: Dielectric test, phase to phase and phase to ground, at twice the rated voltage plus 1,000 volts (1,500 volts minimum) for one minute. Date of test and the name and title of the individual certifying the test are indicated on a label affixed to the equipment.

1. Main Bus: As described hereinafter.

2. Switchboard arrangement shall be such that the lowest current carrying parts are at least 12 inches (30 cm) above finished floor, and the height shall be as required by space conditions, and no more than as indicated.

3. Service switches for fire pumps, emergency service, required standby power and optional standby power shall be painted fire red. Such switches shall be mounted in sections separated from the rest of the switchboard where local code enforcement authorities so require.

4. The neutral bus in switchboards containing a main service disconnect shall have, at an accessible point as close as practical to the incoming supply connection, a removable link section. The neutral bus shall be bonded to the ground bus hereinafter specified by means of a connection consisting

of two paralleled 500 MCM copper insulated cables made on the line side of the removable link section.

5. "Spaces only" for overcurrent protection and switching devices shall be bussed for the maximum device that can be fitted into them.

6. Switchboard construction shall be such that where 100 percent rated overcurrent protection and switching devices have been specified such devices shall be able to carry 100 percent of their rated load continuously when mounted in its enclosure.

7. Fusible switch units shall incorporate fuse clips intended to prevent the use of improper fuses. Refer to specification section entitled "Selection of Overcurrent Devices" for fuse types. Modify or replace in field any incorrect fuse clips.

8. Enclosure: Steel. NEMA 250, Type 3R.

9. Enclosure Finish: Factory applied finish manufacture's standard gray finish over a rust inhibiting primer on treated metal surface.

10. Removable Hinged Rear Covers: Secured by captive thumb screws, for access to rear interior of switchboard.

11. Pull Box on Top of Switchboard: Provide where indicated or where required by installation conditions, and include the following features:

    (a) Adequate ventilation to maintain air temperature in pull box within same limits as switchboard.

    (b) Removable covers forming top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.

    (c) Bottom shall be of insulating, fire-resistant material with separate holes for cable drops into switchboards.

    (d) Cable supports shall be arranged to facilitate cabling, and adequate to support cables indicated including those for future installation.

12. Buses and Connections: Three-phase, four-wire except as otherwise indicated. Features shall be as follows:

    (a) Phase and Neutral Bus Material: Hard-drawn copper of 98 percent conductivity.

    (b) At load terminals of feeder breakers, provide silver-plated copper bus extensions equipped with pressure terminal connectors for outgoing circuit conductors.

    (c) Ground Bus: 1/4-inch by 3-inch (6mm by 75mm) minimum size, hard-drawn copper of 98 percent conductivity, and equipped with pressure connector terminations for feeder- and branch-circuit ground conductors.

(d) Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.

(e) Contact Surfaces of Buses: Silver plated.

(f) Main Phase Buses, Neutral Bus, and Equipment Ground Bus: Uniform capacity the entire length of the switchboard main and distribution sections. Provide for future extensions from either end by means of bolt holes or other approved method and connecting links.

(g) Neutral Buses: 100 percent of the ampacity of the phase buses except as indicated, equipped with approved pressure connector terminations for outgoing circuit neutral cables. Provide braced neutral bus extensions for busway feeders with neutral conductors.

13. Future Devices: Equip compartments with mounting brackets, supports, bus connections and appurtenances at full rating of device compartments.

2.3 TRANSIENT VOLTAGE SUPPRESSION DEVICES (TVSS's)

A. Refer to Division 16 Section,"Transient Voltage Suppression" for devices.

2.4 SURGE ARRESTERS

A. Surge Arrester: Distribution class, metal-oxide-varistor type. UL listed for the purpose. One surge arrester for each ungrounded conductor.

1. Install in cable termination compartments and connect in each phase of incoming circuit ahead of any disconnecting device.

2. Coordinate rating with circuit voltage.

3. Comply with IEEE C62.11 and NEMA LA 1.

B. Comply with NFPA 70, Article 280 "Surge Arresters".

C. Comply with NFPA 780, "Standard for the Installation of Lightning Protection Systems".

1. Comply with UL 96A.

2.5 OVERCURRENT PROTECTIVE DEVICES (OCPDs)

A. Comply with requirements of Division 16 Section "Selection of Overcurrent Protective Devices" for types of OCPD's indicated. Provide indicated features, ratings, characteristics, and settings.

B. Future Devices: Where provision for future overcurrent protective devices or space is indicated, equip compartments with mounting brackets, supports, bus connections, and necessary appurtenances, designed for the OCPD types and

ampere ratings indicated for future installation of devices.

C. Fire Pump Devices: Include provision for locking in closed position.

2.6 INSTRUMENTATION

A. Instrument Transformers: NEMA Standard EI 21.1, IEEE for Instrument Transformers," and the following:

1. Metering: Include current transformers (and potential transformers if required) to permit non-revenue metering of each service switch not supplying a fire pump. Transformers shall have ratio and accuracy class suitable for connected meters, instruments and relays.

2. Control Power: Include control power transformer(s) if required by the instrumentation.

B. Multifunction Digital-Metering Monitors: For each set of metering instrument transformers specified above, provide a separate microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with ANSI C12.20 and IEC 687 accuracy:

(a) Phase Currents, Each Phase and Neutral current.
(b) Phase-to-Phase Voltages, Three Phase.
(c) Phase-to-Neutral Voltages, Three Phase.
(d) Kilowatts.
(e) Kilovars.
(f) Power Factor.
(g) Frequency.
(h) Kilowatt Demand: demand interval programmable from 5 to 60 minutes.
(i) Accumulated Energy, Kilowatt Hours.
(j) Time stamped maximum and minimum readings for every measured parameter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

3. Monitor shall provide multiple digital communications ports and support multiple open protocols.

(a) Standard RS-485 and RS-232 ports.
(b) Ethernet port as an available option.
(c) Internal modem as an available option.
(d) Modbus and DNP 3.0 open protocols as standard configurations. All instantaneous data, logged data, event data, power quality analysis and waveform information shall be available using these open protocols.

4. Monitor shall be equipped with non-volatile RAM for recoding logs; capable

of storing 3 months of power demand data. Such data is accessible locally by downloading to a laptop computer, or remotely through RS-485 communications.

5. Monitor shall be programmable by software supplied by the meter manufacturer.

   (a) Software shall have a user-friendly, Windows compatible interface.
   (b) Software shall include capacity to program meter, download meter, and analyze downloaded data files.
   (c) Software shall store all data in a ODBC compliant data base.

6. As manufactured by Power Management, Ltd; ElectroIndustries, or Cutler Hammer.

7. Ground fault current tripping of service disconnect devices larger than 800 amps shall be incorporated in the main switchboard(s) as described in the specification section titled "Selection of Overcurrent Protection Devices." Such tripping shall be as follows:

   (a) It shall include all required current transformers and/or sensors, relays, power supplies, test provisions, miscellaneous items and interwiring. Such items may be integral with the overcurrent protection and switching device (OCD) and/or separately (factory) installed. Pickup and time delay settings shall be field adjustable, and shall be initially set in accordance with manufacturer's recommendations.

8. Where two stages of ground fault tripping have been specified for incorporation in the main switchboard(s) and/or in downstream panelboards settings shall be such as to provide a fully coordinated system such that only the downstream device trips in response to ground faults downstream of it.

2.7 CONTROL POWER

A. General: Where required for electrically operated devices or ground fault relays, provide 120-V control circuits supplied through secondary disconnect devices from control power transformer.

B. Control Power Fuses: Include primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory-installed, complete with bundling, lacing, and protection. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.8 RATINGS

A. Provide nominal system voltage, continuous main bus amperage, and short-circuit-current ratings as indicated.

B. Short circuit rating: Not less than 65,000 amps RMS symmetrical. Switchboard

shall bear a manufacturer's label attesting thereto. If multiple labels are required to attest to complete compliance, such labels shall be provided. Compliance shall be on a "fully rated" rating basis.

C. Main bussing indicated on the drawings with an ampere designation shall be sized based on a rating of 1000 amps per square inch (155 amps per square centimeter). Where no designation is indicated, or where the sum of the service switches (switch sizes or circuit breaker frame sizes) exceeds the indicated ampere designation for the main bus, the main bus size shall be based on an ampacity equal to the sum of the service switches (except that it need not exceed 6 square inches (39 square centimeters) in cross section regardless of the indicated ampere designation. Where spaces for future service switches have been incorporated, the main bus sizing shall take this into account.

D. The size of bussing, from mains to line studs of devices, other than those in panelboard type sections shall be such that no section of bus shall have a rating less than the total of switch sizes or circuit breaker frame sizes which it supplies, if for (1) or (2) devices, nor less than 80 percent of the total if for (3) or (4) devices, nor less than 70 percent of the total if for more than (4) devices. In no case, however, shall it exceed the rating of the main bus. Bus ratings shall be based on current density of not more than 1000 amps per square inch (155 amps per square centimeter).

E. Where bussing is extended beyond the confines of the switchboards for ties to service connection points or ties between separately mounted switchboard sections it shall conform to all switchboard main bus requirements set forth above except that:-

1. It shall be sized based on a maximum current density of 500 amps per square inch (58 amps per square centimeter) subject to the limitation that it need not exceed 8 square inches (52 square centimeters) in cross section.

2. It shall have each of its bars wrapped with two half lapped layers of approved fireproofing tapes of types specifically manufactured for the purpose.

3. Its housing, for its full length, shall include on the inside a ground bar of at least 1-1/2 square inches (10 square centimeters) cross section or to which housing framing members are bonded. For ties between separately located switchboard sections, this ground bar shall be in addition to the switchboard ground bar hereinbefore specified.

2.9 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: Arranged to permit testing of all functions of solid-state trip devices without removal from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

C. Spare Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented, steel box or cabinet. Arrange for wall mounting.

2.10 IDENTIFICATION

A. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram. Coordinate mimic-bus segments with devices in switchboard sections to which applied. Produce a concise visual presentation of principal switchboard components and connections.

1. Presentation Media: Painted graphics in color contrasting with equipment factory-finished background to represent bus and components, complete with lettered designations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchboards and accessory items according to NEMA PB2.1.

B. Anchor each switchboard assembly to two 4-inch-minimum channel-iron sills arranged in accordance with manufacturer's recommendations. Attach by tack welding or bolting. Level and grout sills flush with switchboard mounting surface.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Operating Instructions: Frame and mount printed, basic operating instructions for switchboards, including control and key interlocking sequences, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on the front of the switchboards.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section "Electrical Identification."

B. Switchboard Nameplates: Label each switchboard compartment with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Install equipment grounding connections for switchboards with ground continuity to main grounding electrode.

B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Testing Agency: Engage a qualified independent testing agency to perform specified testing.

C. Testing: After installing switchboards and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.

1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Sections 7.1, 7.5, 7.6, 7.9, 7.10, 7.11, and 7.14 as appropriate. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies switchboards checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.6 CLEANING

A. On completion of installation, inspect interior and exterior of switchboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16441

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SECTION 16442 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following:

1. Lighting and appliance branch circuit panelboards.

2. Power and distribution panelboards.

B. Related Sections include the following:

1. Division 16 "Selection of Overcurrent Devices" for overcurrent protection program.

2. Division 16 Section "Fuses".

3. Division 16 Section “Transient Surge Suppressors” for surge protection.

1.3 DEFINITIONS

A. Overcurrent Protective Device (OCD) (OCPD): A device operative on excessive current that causes and maintains the interruption of power in the circuit it protects.

1.4 SUBMITTALS

A. Product Data: For each type of panelboard, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings. Include the following:

(a) Enclosure types and details for types other than NEMA 250, Type 1.

(b) Bus configuration, current, and voltage ratings.

(c) Short-circuit current rating of panelboards and overcurrent protective devices.

(d) UL listing for series rating of installed devices where applicable.

(e) Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

C. Field Test Reports: Submit written test reports and include the following:

1. Test procedures used.

2. Test results that comply with requirements.

3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

E. Operation and Maintenance Data: For panelboards and components to include in maintenance manuals specified in Division 1. In addition to requirements specified in Division 1 Section "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

2. Time-current curves, including selectable ranges for each type of overcurrent protective device.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, OCD's, components and accessories through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by Underwriters Laboratories Inc.

C. Comply with NEMA PB 1.

D. Comply with NFPA 70 as amended by state and local codes.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:

1. Ambient Temperature: Not exceeding 104 degrees F (40 degrees C).

2. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Condition: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperature within limits specified.

2. Altitude not exceeding 6600 feet (2000 m).

1.7 COORDINATION

A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Panelboards and Accessories:

(a) Eaton Corp.; Cutler-Hammer Products.

(b) General Electric Co.; Electrical Distribution & Control Div.

(c) Siemens Energy & Automation, Inc.

(d) Square D Co.

2.2 MANUFACTURED UNITS

A. Factory tests: Dielectric test, phase to phase and phase to ground, at twice the rated voltage plus 1,000 volts (1,500 volts minimum) for one minute. Date of test and the name and title of the individual certifying the test shall be indicated on a label affixed to the equipment.

B. Enclosures: Flush- and surface mounted cabinets. NEMA PB 1, Type 1, to meet environmental conditions at installed location.

1. Outdoor Locations: NEMA 250, Type 3R.

2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.

3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

C. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

D. Finish: Manufacturer's standard enamel finish over corrosion-resistant treatment or primer coat.

E. Directory Card: With transparent protective cover, mounted inside metal frame, inside panelboard door.

F. Bus: **Hard-drawn copper, 98 percent conductivity, or Tin-plated aluminum.**

G. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL

listed as suitable for nonlinear loads.

H. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment ground conductors; bonded to box.

I. Isolated Equipment Ground Bus: Adequate for branch-circuit equipment ground conductors; insulated from box.

J. Main and Neutral Lugs: Type suitable for use with conductor material. **[Compression type for aluminum.]**

K. Feed-through Lugs: Type suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device. [**Compression type for aluminum.]**

L. Future Devices: Mounting brackets, bus connections, and necessary appurtenances required for future installation of devices.

M. Where wires or cables are used within panelboards to make up internal connections (factory installed or otherwise) such wire or cable shall have copper conductors only.

N. Where indicated or as required to assure ready accessibility of top switching and overcurrent device, they shall be arranged as multiple adjacent sections. A single overall cabinet shall be supplied for the multiple adjacent sections which constitute one panel. 1/4 inch (7 mm) minimum thickness plastic barriers having adequate angle iron framing support all around shall be included between sections. The entire assembly shall be such as to include wiring gutter space for each section as if it were an individual panelboard. Common bussing shall be arranged for adjacent sections unless there is indication that the individual sections are to be separately supplied. Sub-feed lugs with full capacity cable taps to adjacent panel sections will be accepted as the bussing method.

2.3 POWER OR DISTRIBUTION PANELBOARDS

A. Doors: Secured with vault-type latch with tumbler lock; keyed alike. Omit for fused-switch panelboards.

B. Main Overcurrent Protective Devices and Branch Overcurrent Protective Devices: as specified in Division 16, Section “Selection of Overcurrent Devices.”

C. Cabinet: width and a depth adequate for a three pole branch device equal in rating to the panel mains. In no case shall the cabinet be wider than 42 inches (106 cm) or deeper than 18 inches (46 cm).

2.4 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

B. Doors: Concealed hinges, secured with flush latch with tumbler lock.

C. Gutter space: adequate space for connecting to all active and spare branches.

D. Cabinet width: not to exceed 24 inches (61 cm).

E. Cabinet depth: not to exceed 6 inches (15 cm).

F. Manufacturer's label: stipulating its short circuit current rating as **100,000 amps** on a "series connected" basis in conjunction with Class "T" fuses incorporated integrally, Class "T" fuses and tenant main breakers incorporated in metering assemblies, circuit breakers as specified in Division 16 Section “Selection of Overcurrent Devices”.

2.5 PANELBOARD BUSES

A. The neutral buses of 120/208 volt panels supplying "harmonic-rich" line-to-neutral loads shall have ampacities larger than those of the phase legs in such panels in accordance with the following criteria:

1. In no case shall the neutral bus ampacity of any panel supplied by a feeder with a neutral conductor which is larger than the phase conductors be less than the lesser of:

   (a) The ampacity of the neutral conductor of the feeder supplying the panel.

   (b) Twice the ampacity of the upstream overcurrent device protecting the feeder supplying the panel.

2. The above requirements for the sizing of panel neutral buses shall override any indications on the drawings that smaller neutral buses are acceptable.

3. Neutral buses shall be equipped with lugs capable of accepting single conductors (i.e., not paralleled) of an ampacity equal to the neutral bus rating (except where the neutral bus rating exceeds 400 amps).

4. If required by manufacturer in order to comply with increased neutral bus sizing criteria specified above, increase phase leg bussing, as well.

5. Refer to the light and power riser diagram or to other electrical drawings to determine which panels - if any - are supplied by feeders having "over-sized neutrals" and therefore require up-sizing of the panel neutral bus.

B. A ground bus shall be provided for each panel. The ground bus shall be insulated from the panelboard cabinet.

2.6 OVERCURRENT PROTECTIVE DEVICES

A. As described in Division 16 Section “Selection of Overcurrent Devices”.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items as required for overcurrent protective device test, inspection, maintenance, and operation.

B. Switch and fuse units incorporated as part of panelboards shall be equipped with factory installed rejection clips to restrict fuses to types specified in Division 16, Section "Selection of Overcurrent Devices." Modify or replace in field any incorrect fuse clips.

C. Provide "lock-on" clips for the toggle handles of 5 percent of the branches in all lighting and appliance panels. Apply these clips to circuits supplying clocks, fan coil units and others as directed in the field.

D. Furnish handle padlock attachments for 5 percent of the branches in lighting and appliance panels, and padlocks (with key) for 10 percent of these padlock attachments, but not less than 10 locks. Apply the padlock attachments to circuits (as directed in the field) for which the branch circuit device must be lockable in the "off" position in order to provide code-approved disconnect means.

2.8 PANELBOARD SHORT CIRCUIT RATINGS

A. Panelboards and Panelettes (load centers) shall bear U.L. labels attesting to the adequacy of the equipment to withstand and interrupt short-circuit currents not less than those available at their incoming terminals. Panels shall either be fully rated or shall be series rated in conjunction with integral or remote upstream devices in compliance with Division 16 Section “Selection of Overcurrent Devices”. U.L. labels shall include size and type of allowable upstream and branch circuit devices and series connected ratings.

B. Panelboard short circuit ratings shall comply with the coordination study per specification section 16055.

C. EMERGENCY SYSTEMS AND LEGALLY REQUIRED STANDBY SYSTEMS: Overcurrent devices shall be selected such that distribution system is selectively coordinated. Series rated devices shall not be used for distribution, regardless of any indication to the contrary. Short circuit rating of panelboards and devices shall be as required for a fully rated system. For lighting and appliance panelboards which are not available with integral main overcurrent devices, provide individually enclosed main device located adjacent to panel complete with interconnecting circuitry.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards and accessories according to NEMA PB 1.1.

B. Mount top of trim 74 inches (188 cm) above finished floor, unless otherwise indicated.

C. Mount plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish.

D. Install overcurrent protective devices and controllers.

1. Set field-adjustable switches and circuit-breaker trip ranges.

E. Install filler plates in unused spaces.

F. Stub four 1-inch (DN 25) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (DN 25) empty conduits into raised floor space or below slab not on grade.

G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 16 Section “Electrical Identification."

B. Create a directory to indicate installed circuit loads. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with engraved metal or laminated-plastic nameplate mounted with corrosion-resistant screws.

3.3 CONNECTIONS

A. Ground equipment according to Division 16 Section "Grounding and Bonding."

B. Connect wiring according to Division 16 Section "Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.

2. Test continuity of each circuit.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.

2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.

2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.

3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

D. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scanning of each panelboard. Remove panel fronts so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

2. Record of Infrared Scanning: Prepare a certified report that identifies panelboards checked and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 CLEANING

A. In completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 16442

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SECTION 16461 - DRY TYPE TRANSFORMERS (600 VOLTS AND LESS)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes dry-type distribution and specialty transformers rated 1000 V and less.

1.3 SUBMITTALS

A. Product Data: Include data on features, components, ratings, and performance for each type of transformer specified. Include dimensioned plans, sections, and elevation views. Show minimum clearances and installed devices and features.

B. Wiring Diagrams: Detail wiring and identify terminals for tap changing and connecting field-installed wiring.

C. Product Certificates: Signed by manufacturers of transformers certifying that the products furnished comply with requirements.

D. Field Test Reports: Indicate and interpret test results for tests specified in Part 3.

E. Maintenance Data: For transformers to include in the maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

A. Listing and Labeling: Provide transformers specified in this Section that are UL listed and labeled.

1. The Terms “Listed” and “Labeled”: As defined in NFPA 70, Article 100.

B. Comply with IEEE C2.

C. Comply with NFPA 70.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer’s written instructions within the enclosure of each ventilated-type unit throughout periods during which equipment is not energized and is not in a space that is continuously under normal control of temperature and humidity.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Transformers:

(a) MagneTek, Inc.

(b) Olsun Transformers

(c) Square D; Groupe Schneider

2.2 TRANSFORMERS, GENERAL

A. Transformers: Factory-assembled and -tested, air-cooled units of types specified, designed for 60-Hz service.

B. Cores: Grain-oriented, nonaging silicon steel.

C. Coils: Continuous windings without splices except for taps.

D. Internal Coil Connections: Brazed or pressure type.

E. Enclosures: Class complies with NEMA 250 for the environment in which installed.

2.3 GENERAL-PURPOSE, DRY-TYPE TRANSFORMERS

A. Comply with NEMA Standard ST 20 and list and label.

B. Comply with NEMA Class 1 efficiency levels for Dry Type Distribution Transformers as tested and rated in accordance with NEMA Standard TP 1

C. Transformers: Two-winding type, 3-phase units using 1 coil per phase in primary and secondary.

D. Windings: Copper **[or aluminum]**.

E. Features and Ratings: As follows:

1. Enclosure: Indoor, ventilated

F. Insulation Class:

1. Insulation Temperature Rise: 115 deg C maximum rise above 40 deg C.

G. Taps: For transformers 3 kVA and larger, full capacity taps in high-voltage winding are as follows:

1. Six 2.5-percent taps, 2 above and 4 below rated high voltage.

H. K-Factor Rating: Comply with UL 1561 requirements for non-sinusoidal load current capability as noted below.

1. All transformers specifically identified as "K-Rated" shall be suitable for carrying continuously non-linear (i.e., non-sinusoidal) loads equal to 100% of their nameplate rating without exceeding an average temperature rise of 115°C. This suitability shall be based on loads having a "K-Factor" of 13, and shall apply regardless of the harmonic current distribution making up the "K-13" loading. These transformers shall comply with all of the requirements specified hereinbefore for transformers which are not K-Rated and additionally shall each comply with the following:

(a) It shall bear a UL label stating its suitability for K-13 loads.

(b) Its primary winding conductors shall be sized so as to limit temperatures to the values stipulated above taking into account the circulating currents produced by the 3rd, 9th and 15th harmonics.

(c) Its secondary winding neutral conductors and terminal shall be sized to have twice the ampacity of the phase conductors.

(d) Core and winding design shall be such as to minimize eddy current losses and to reduce the core flux density well below the saturation point to prevent core overheating caused by harmonic distortion.

(e) It shall be provided with an electrostatic shield between windings.

I. Mounting: Transformers up top and including 15 KVA shall be equipped with brackets suitable for wall mounting. Larger than 15 KVA, they shall be suitable for platform or floor mounting.

2.4 CONTROL AND SIGNAL TRANSFORMERS

A. Units comply with NEMA Standard ST 1, and are listed and labeled as complying with UL 506.

B. Ratings: Continuous duty. If capacity is not indicated, provide capacity exceeding peak load by 50 percent minimum.

C. Description: Self-cooled, 2-winding, dry type.

D. Enclosure: Suitable for the location where installed.

2.5 FINISHES

A. Indoor Units: Manufacturer's standard paint over corrosion-resistant pretreatment and primer.

2.6 SOURCE QUALITY CONTROL

A. Factory Tests: Design and routine tests conform to referenced standards.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with safety requirements of IEEE C2.

B. Arrange equipment to provide adequate spacing for access and for cooling air circulation.

C. Identify transformers and install warning signs according to Division 16 Section "Electrical Identification."

D. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not furnished, use those specified in UL 486A and UL 486B.

E. Wall mount transformers 15 KVA and less. Suspend transformers larger than 15 KVA and in sizes up to and including 75 KVA from the structure to overhead. Utilize trapeze type hanger arrangements for the purpose. Floor mount all transformers larger than 75 KVA.

F. Coordinate location of ceiling suspended transformers with building structure and with equipment in closet so as to insure accessibility and working clearances. If necessary, to so insure, floor mount transformers in lieu of suspending them. Modify closet layout accordingly.

G. Floor or wall supported transformers shall be resiliently isolated from the building structure by means of neoprene in shear isolators providing a minimum static deflection of 3/8 inch.

H. Ceiling supported transformers shall be resiliently suspended by means of neoprene in shear hanger rod isolators providing a minimum static deflection of 3/8 inch.

3.2 GROUNDING

A. Ground transformers and systems served by transformers according to Division 16 Section "Grounding."

3.3 FIELD QUALITY CONTROL

A. Test Objectives: To ensure transformer installation is operational within industry and manufacturer's tolerances, install according to Contract Documents, and suitable for energizing.

B. Test Labeling: Upon satisfactory completion of tests for each unit, attach a dated and signed "Satisfactory Test" label to the tested component.

C. Schedule tests and provide notification at least one week in advance of test commencement.

D. Report: Submit a written report of observations and tests. Report defective materials and workmanship.

E. Tests: Include the following minimum inspections and tests according to the manufacturer's instructions. Conform to IEEE C57.12.91 for test methods, and data correction factors.

1. Inspect accessible components for cleanliness, mechanical, and electrical integrity, for presence of damage or deterioration, and to ensure removal of temporary shipping bracing. Include internal inspection through access panels and covers.

2. Inspect bolted electrical connections for tightness according to manufacturer's published torque values or, where not available, those of UL standards 486A and 486B.

3. Insulation Resistance: Perform megohmmeter test of primary and secondary winding-to-winding and winding-to-ground.

(a) A minimum test voltage: 1,000 V d.c.
(b) Minimum insulation resistance: 500 megohms.

(c) Duration of Each Test: 10 minutes.

(d) Temperature Correction: Correct results for test temperature deviation from 20 deg C standard.

F. Test Failures: Correct deficiencies identified by tests and retest. Verify that equipment meets the specified requirements.

3.4 CLEANING

A. On completion of installation, inspect components. Remove paint splatters and other spots, dirt, debris. Repair scratches and mars on finish to match original finish. Clean components internally using methods and materials recommended by manufacturer.

3.5 ADJUSTING

A. After completing installation, cleaning, and testing, touch up scratches and mars on finish to match original finish.

B. Adjust transformer taps to provide optimum voltage conditions at utilization equipment throughout the normal operating cycle of the facility. Record voltages and tap settings to submit with test results.

END OF SECTION 16461

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SECTION 16491 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and spare fuse cabinets.

1.3 SUBMITTALS

A. Product Data: Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings for each fuse type indicated.

B. Product Data: Include the following for each fuse type indicated:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.

2. Let-through current curves for fuses with current-limiting characteristics.

3. Time-current curves, coordination charts and tables, and related data.

4. Fuse size for elevator feeders and elevator disconnect switches.

C. Maintenance Data: For fuses to include in emergency operation and maintenance manuals.

1. In addition to terms specified in Division 1 Section “Operation and Maintenance Data”, include the following:

(a) Let-through current curves fuses with current-limiting characteristics.

(b) Time-Current curve, coordination charts and tables, and related data.

1.4 QUALITY ASSURANCE

A. Source Limitations: Provide fuses from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with NEMA FU 1.

D. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (4.4 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

[1.6 COORDINATION

A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.7 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged in original cartons or containers and identified with labels describing contents.

1. Fuses: Quantity equal to 10 percent of each fuse type and size, but not fewer than 3 of each type and size.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Cooper Bussman, Inc.

2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.

3. Ferraz Shawmut.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch-1.27-mm- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.

2. Finish: Gray, baked enamel

3. Identification: "SPARE FUSES" in 1-1/2-inch (40-mm) high letters on exterior of door.

4. Fuse Pullers: For each size fuse.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

A. Refer to Division 16, Section “Selection of Overcurrent Devices for Determination of Fuse Types for Installation Throughout the Distribution System.

3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install spare fuse cabinet[**s**].

3.4 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

B.

END OF SECTION 16491

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SECTION 16496 - PROVISIONS FOR ELEVATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section includes power, lighting, communications and alarm provisions for elevators.

1.3 QUALITY ASSURANCE

A. Comply with NFPA 70 for devices and installation.

B. Listing and Labeling: Provide products that are Underwriter's Laboratories listed and labeled for their applications and installation conditions and for the environments in which installed.

1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

PART 2 - PRODUCTS

Products shall be as specified in other Sections of Division 16.

PART 3 - EXECUTION

3.1 APPLICATION

A. In addition to the power feeder and disconnect switch at the entry to the room (whether incorporated in a power panelboard or individually mounted) for each elevator, as shown on the drawings, further electrical work is required as described hereinafter.

3.2 INSTALLATION

A. An additional disconnect switch shall be provided for any elevator where the hoist motor is not "in sight" of the disconnect switch (individual or in panelboard) located at the entry to the room. This switch shall be interposed in the feeder to the elevator controller at a suitable location approved as "in sight" by the authorities having jurisdiction.

B. For elevators supplied from panels not located in the elevator machine room, the disconnects switches located at the entry to the room shall be of the switch and fuse type regardless of any indication to the contrary on the drawings. Fuses shall be sized equal to those upstream of the switches.

C. For each hydraulic elevator, provide a relay (mounted adjacent to the elevator disconnect switch) with wiring so arranged as to prevent the normal "elevator lowering when power fails" sequenced during periods when the elevator controller is manually de-energized for maintenance or other purposes.

D. Unless exceeded by requirements shown on the drawings, or elsewhere in the specifications, provide equipment, circuitry and/or roughing for elevator appurtenances as follows:

1. For each elevator, provide a single circuit 20 amps, 120 volt supply including a fused padlockable disconnect switch located in the elevator machine room or machine space, from an emergency lighting/appliance panel to the elevator controller, numbered to correspond to the identifying number on the elevator cab.

2. For each elevator, provide a single circuit 20 amp, 120 volt supply from an emergency lighting/appliance panel to a "top of shaft trail cable outlet box".

3. For each elevator, provide a vaportight switch, GFCI duplex receptacle and 100 watt lighting fixture with globe and guard. Devices shall be mounted in elevator pit at location as directed in field. Provide circuitry as required.

4. For each elevator provide a "run/by" switch, receptacle and light of type described above. Provide circuitry as required.

5. For each elevator provide secondary (sheave) level switch light and receptacle, complete with circuitry, as described hereinbefore.

6. For each elevator provide top of shaft communication and alarm facilities as follows:

   (a) Telephone outlet box, complete with 3/4" empty conduit to nearest telephone closet facility.

   (b) Fire protective alarm (FPA) system outlet box complete with cable for loudspeaker and intercom station (warden's station) furnished as part of FPA system for installation in elevator cab. Cable should be run to nearest appropriate FPA system equipment cabinet.

   (c) Closed circuit TV (CCTV) outlet box at top of shaft, complete with 3/4" conduit extension to CCTV junction box located in elevator machine room as described hereinafter.

7. For the group controller in each electric hoist elevator machine room, provide a 30 amp, 3 phase, wire supply from the power panel supplying the elevators.

8. For each elevator machine room provide a single 20 amp, 120 volt emergency circuit to the elevator intercom panel (or to the group controller if there is not separate intercom panel).

9. Provide a fused disconnect switch, adjacent to the controller for each connection to a controller or group controller as described hereinbefore.

10. From each elevator shaft (including hydraulic elevators) provide empty conduit (intended for elevator communication, signaling and alarm) to the elevator dispatcher's panel in accordance with the following:

    Up to (4) cars per shaft -- (2) 2 ½" conduits

11. For each elevator machine room provide a 2" empty conduit (intended for closed circuit TV cables) run to the concierges desk security office or elsewhere as directed by the Architect. Conduit shall terminate in CCTV junction box at both ends of run.

12. For each elevator machine room, provide ceiling fixed temperature 135°F heat detectors giving total coverage for the room. Provide similar detectors at the top of each elevator shaft. Connect the detectors together and into the fire alarm system. If any of the heat detectors goes into alarm, after a short, adjustable time delay, a signal shall be transmitted to shut down the power for all elevators served by the machine room. If any of the detectors at the top of the shaft goes into alarm, after a short, adjustable time delay, a signal shall be transmitted to shut down the power to all elevators in the bank. All elevator power shall be able to be re-energized from the fire command station. Provide appropriate electrically operated devices required for the elevator shut-down.

END OF SECTION 16496

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SECTION 16500 - LIGHTING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 16 Section “Basic Electrical Materials and Methods”.

2. Division 16 Section “Supporting Devices”.

3. Division 16 Section “Lighting Control Devices”.

4. Division 16 Section “Wiring Devices”.

1.2 SUMMARY

A. This Section includes interior and exterior light fixtures, emergency lighting units, exit signs, lamps, ballasts and accessories.

1.3 SUBMITTALS

A. For each type of light fixture, emergency lighting unit, or exit sign specified submit data on standard features and accessories, and the following:

1. Outline drawings indicating fixture dimensions.

2. Catalogue cuts for proposed lamps.

3. Performance data for proposed fluorescent and high intensity discharge ballasts.

4. Battery and charger data for emergency lighting units.

5. For air handling fixtures, submit air, thermal, and sound performance data. Provide certified results of independent laboratory tests indicating:

(a) Airflow as a function of pressure differential between plenum and occupied space.

(b) Noise criteria (NC) rating as a function of airflow.

(c) Heat transfer rate as a function of airflow (required for heat removal fixtures only).

B. For nonstandard fixtures, submit detailed shop drawings indicating dimensions, materials, weights, method of field installation and assembly, method of relamping and ballast access, and principal features.

C. Submit project-specific, factory-produced shop drawings for all fluorescent pendants and continuous fluorescent wall-slots. Drawings show housing lengths, joiners, supports, endcaps, corners, and unlighted end sections, as applicable, for all unique row lengths.

D. Submit dimming ballast compatibility certificates signed by the lighting control system manufacturer certifying that proposed dimming ballasts are compatible with proposed dimming systems.

E. Submit samples of fixtures as directed by Architect, Engineer, or Lighting Designer. Unless otherwise noted, all samples are provided with specified lamp(s) and ballast(s), and are equipped with a cord and plug for operation at 120V.

F. If shop drawings are submitted for a specific fixture type by a non-specified manufacturer, and approvals cannot be obtained by the third submission, then the proposed equipment will not be accepted and the specified equipment is furnished.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70 as amended by state and local codes.

B. Electrical Components of fixtures are listed and labeled by UL where applicable.

C. Provide fixtures and accessory components specified in this Section that are listed and labeled for their indicated use and installation conditions on Project.

1. Fixtures specified for installation in damp or wet locations are listed and labeled for use in such locations.

2. Fixtures specified for installation in insulated ceilings are IC-rated if insulation comes within 3 inches (76 mm) of sides of fixture housings, or within 6 inches (152 mm) of top of fixture housings.

3. Fixtures specified for installation in hazardous locations conform to UL 844.

D. The Terms "Listed" and "Labeled" are used here as per the definitions in the National Electrical Code, Article 100.

1.5 COORDINATION

A. For ceiling-mounted fixtures, coordinate fixtures, mounting hardware, and trim with ceiling system and other items, including work of other trades, which must be mounted on ceiling or in ceiling space.

B. Lighting fixtures, ballasts, lamps and other components meet or exceed the requirements of all applicable federal, state, and/or municipal energy codes.

C. Coordinate lamps and dimming ballasts with lighting control systems. Before ordering any equipment, verify with manufacturers that proposed dimming ballasts are compatible with proposed lighting controls, and that proposed lamps are compatible with proposed dimming ballasts.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with project requirements, fixtures that may be incorporated into the Work include, but are not limited to, the products specified in the Light Fixture Schedule. Where three or more manufacturers are indicated for each fixture type, no other manufacturers will be considered. Where one manufacturer is indicated for each fixture type, other manufacturers will be considered only if the engineer, architect, or lighting consultant can determine that the proposed equipment is equal to the specified equipment.

2.2 LIGHT FIXTURES AND FIXTURE COMPONENTS, GENERAL

A. Light fixtures and components are suitable for operation at the voltage of the building circuits to which they are connected.

B. Light fixtures are furnished complete with all appurtenances necessary for their proper operation, installation, and support.

C. Light fixtures conform to the following standards as applicable:
1. Fluorescent Fixtures conform to UL 1570.

2. Incandescent Fixtures conform to UL 1571.

3. High Intensity Discharge (HID) Fixtures conform to UL 1572.

4. Track-Lighting Systems conform to UL 1574.

5. Exit Signs conform to UL 924.

6. Christmas-Tree and Decorative-Lighting Outfits conform to UL 588.

D. General Construction:

1. Light fixtures are constructed with joints made only by means of welded, brazed, screwed, or bolted construction methods. Soldered joints will not be permitted. No self-tapping screws, bled metal tapping methods, or rivets are employed for fastening any parts to or in any wireway or wiring chamber, for fastening any parts which must be removed to gain access to electrical components requiring service or replacing, or for fastening any electrical component or support for same.

2. All ferrous parts and supports, other than parts manufactured of stainless steel, are completely rustproofed after fabrication, and before finish coatings are applied. Rustproofing is by means of galvanizing, bonderizing, zinc plating, or by treatment with other industry standard rust-preventing processes providing rustproofing qualities equal to the processes mentioned above.

3. All screws, bolts, nuts and other fastening and latching hardware are cadmium or equivalent plated.

4. All metallic cast or extruded parts are close grained, sound, and free from imperfections or discolorations. Cast or extruded parts are rigid, true to pattern, and of ample weight and thickness. Cast or extruded parts are properly fitted, filed, ground buffed, and chased to provide finished surfaces and joints free of imperfection with all details or ornamentation brought out. Finished thickness of all cast parts is not less than 1/8 inch (3 mm).

5. Housings are constructed so that all electrical components are easily accessible and replaceable without removing housings from their mountings.

E. Sheet metal components are fabricated of steel, except as indicated. Form and support sheet metal to prevent warping and sagging.

F. Doors, frames, and other means of internal access operate smoothly, free from light leakage under operating conditions, and are arranged to permit relamping without use of tools, unless indicated otherwise on drawings. Arrange doors, frames, lenses, diffusers, and other pieces to prevent accidental falling during relamping and when secured in operating position.

G. Specular, semi-specular, and laminated silver metallized film reflectors have a non-iridescent coating when used with triphosphor fluorescent lamps. Reflectors have total hemispheric reflectances equal to or greater than the following values, unless otherwise noted:

1. White surfaces: 90 percent.

2. Specular surfaces: 87 percent.

3. Semi-specular surfaces: 84 percent.

4. Laminated silver metallized films: 95 percent.

H. Lenses and diffusers are 100 percent virgin acrylic, tempered annealed glass, or cast glass unless otherwise noted. When polycarbonate lenses are specified, they have a high resistance to yellowing or brittleness due to exposure to heat or ultraviolet radiation. Polystyrene lenses are not provided under any circumstances. Lens thickness is at least 1/8 inch (3mm), unless otherwise noted.

I. Fixture support components comply with Division 16, Section “Supporting Devices”

1. Single-stem hangers are 1/2-inch (13mm) minimum diameter steel or aluminum tubing with swivel ball fitting and ceiling canopy arranged so that stems hang vertically regardless of the angle of the surface they are mounted from. Finish of stems and canopy plates are same as fixture unless otherwise noted.

2. Hook hangers are only provided where specified. Hook hangers are integrated assemblies matched to fixture and line voltage and equipped with threaded attachment, cord, and locking-type plug.

3. Provide pendant mounting hardware for fixture types indicated as suitable for surface or pendant mounting in accordance with instructions issued during construction or as required by job conditions.

4. Wherever a fixture or its hanger canopy is applied to a surface mounted outlet box, a finishing ring (escutcheon) is utilized to conceal the outlet box.

5. Unless otherwise noted, linear fluorescent pendants are provided with aircraft cable supports, with power fed through a single straight white cord at one end of each row. When multiple independent feed points are required to satisfy circuitry requirements (e.g. when a continuous pendant row has both emergency and normal sections), locate feeds at two ends of row.

J. Lampholders are suitable for operation of the specified lamps and are set so that lamps are positioned in optically correct relation to all light fixture components. All lampholders comply with applicable requirements of ANSI C81. All fluorescent lampholders comply with UL 542.

K. Fixtures for use in damp or wet locations are suitably gasketed to prevent the entrance of moisture.

L. Air-handling fixtures comply with the following:

1. Sound Transmission Class (STC) conform to ADC Standard AD 63.

2. Supply Units are equipped with slots in one or both side trims and joined with air-diffuser boot assemblies specified in Division 15.

3. Heat Removal Units provide an air path through the lamp cavity to reduce heat buildup.

4. Air Return Units are equipped with slots on either side of the diffuser to allow air return through fixture into ceiling plenum.

5. Static Fixtures have slots blanked, with fixture appearance matching active units.

M. Fixtures utilizing ballasts or transformers bear identification, by means of a label on the reflector or body, of the circuit voltage at which they are intended to operate.

N. All high intensity discharge (HID) fixtures circuited for emergency operation are equipped with auxiliary instant-on quartz systems (also known as a quartz restrike systems). Each fixture is equipped with an auxiliary quartz lamp that is automatically switched on whenever the fixtures are energized (e.g. after a temporary power interruption) and automatically switched off when the high intensity discharge lamp reaches approximately 60 percent light output. The control circuitry that switches the quartz lamp is integral to the fixture.

O. Recessed incandescent lighting fixtures incorporate integral thermal protection. When specified in fixture schedule, provide fixtures with special wattage reduction labels for compliance with energy codes.

P. All components of track lighting systems, including track, fittings, and fixtures, are provided by one manufacturer.

Q. Fixtures are complete with all internal wiring and all flexible conduits, pigtails, and the like necessary for external connections. All wire utilized for connections to or between individual lamp sockets and lamp auxiliaries (i.e., wires which do not constitute "through circuit" wiring) are minimum #16 gauge, industry standard, fixture wire suitable for the temperature, current and voltage conditions to which it is subjected. Internal wiring contains a minimum number of splices. Splices in internal wiring are made with approved insulated "wire nut" type mechanical connectors, suitable for the temperature and voltage conditions to which they are subjected.

R. Grounding-type flexible conduit is used for light fixture pigtails, and grounding type connectors are used for installing same. Include grounding conductor if upstream overcurrent device exceeds 20 amps.

S. Fluorescent fixtures specified with integral emergency battery packs (also known as emergency ballasts) incorporate a test switch and indicator light within the fixture. Test switch and indicator light are discretely located, so that they are not visible from ordinary viewing angles, but so that they are readily accessible to maintenance personnel, as required by code. Fixtures incorporating emergency battery packs are wired so that they may be switched or dimmed as part of their assigned lighting control zone without causing the battery pack to energize the lamps.

2.3 BALLASTS

A. General Requirements: Provide ballasts as indicated in the Light Fixture Schedule. If specific ballasts are not identified in the Light Fixture Schedule, provide ballasts as indicated below:

1. Fixtures with T-8 linear and U-bent fluorescent lamps are provided with instant start solid-state electronic ballasts.

2. Fixtures with T-5 standard and high-output linear fluorescent lamps are provided with programmed rapid start solid-state electronic ballasts.

3. Fixtures with T-5 "biax" 2G11-base lamps (excluding NEMA FT40W) are provided with programmed rapid start solid-state electronic ballasts.

4. Fixtures with 40W T-5 "biax" 2G11-base lamps (NEMA FT40W) are provided with instant start solid-state electronic ballasts.

5. Fixtures with T-4 "quad tube" and "triple tube" compact fluorescent lamps (NEMA CFQ and CFM) are provided with programmed rapid start solid-state electronic ballasts.

6. Fixtures with T-4 "twin tube" compact fluorescent lamps rated 13W or lower (NEMA CFT13W, CFT9W, and CFT7W) are provided with preheat electromagnetic ballasts.

7. Fixtures with HID lamps are provided with electromagnetic ballasts.

B. Instant start electronic ballasts comply with the following:

1. Ballasts for T-8 lamps operate from a 50/60 Hz input source of 108-305 volts with no damage to the ballasts.

2. Input current Total Harmonic Distortion (THD) does not exceed 10 percent.

3. Power factor is 0.90 or greater.

4. Provide 2-, 3-, or 4-lamp ballasts for multilamp fixtures wherever possible. All multilamp ballasts operate lamps in parallel, so that the loss of one or more lamps will not prevent the remaining lamps from functioning properly.

5. Ballast factor is between 0.85 and 0.90 for normal light output ballasts, and a minimum or 1.15 for high light output ballasts. Provide normal light output ballasts unless otherwise specified.

6. Ballasts operate lamps at a frequency of 40 kHz or greater.

7. Ballasts are UL 935 Listed, Class P, Type 1 Outdoor, and CSA certified where applicable.

8. Ballasts meet ANSI C82.11.

9. Ballasts comply with the Federal Communications Commission rules and regulations, Title 47 CFR Part 18 Non-Consumer Equipment for EMI (power line conducted) and RFI (radiated).

10. Ballasts withstand transients as specified in ANSI C62.41.

11. Ballasts have class "A" sound rating.

12. Lamp current crest factor is less than 1.7.

13. Ballasts operate lamps with no visible flicker (3 percent flicker index).

14. Ballasts start and operate T-8 lamps down to 0 degrees Fahrenheit (-18 degrees Celsius) or lower without shortening lamp life.

15. Ballasts are warranted for a minimum of five years. Ballast manufacturer provides replacement ballast and pays all labor costs associated with replacing ballasts that fail during their warranty period.

16. Ballasts are manufactured by one of the following: Universal "Triad HP", Osram/Sylvania "Quicktronic Professional", or Advance "Centium".

C. Programmed rapid start electronic ballasts comply with the following:

1. Ballasts are suitable for operation at the voltage and frequency of the building circuits to which they are connected, and sustained variations of +/- 10 percent (voltage and frequency) with no damage to the ballasts.

2. Input current Total Harmonic Distortion (THD) does not exceed 10 percent.

3. Power factor is 0.90 or greater.

4. Ballasts incorporate lamp shutdown circuitry for end of lamp life protection.

5. Ballast factor is between 0.95 and 1.05.

6. Ballasts operate lamps at a frequency of 40 kHz or greater.

7. Ballasts are UL 935 Listed, Class P, Type 1 Outdoor, and CSA certified where applicable.

8. Ballasts meet ANSI C82.11.

9. Ballasts comply with the Federal Communications Commission rules and regulations, Title 47 CFR Part 18 Non-Consumer Equipment for EMI (power line conducted) and RFI (radiated).

10. Ballasts withstand transients as specified in ANSI C62.41.

11. Ballasts have class "A" sound rating.

12. Lamp current crest factor is less than 1.7.

13. Ballasts start and operate lamps down to 0 degrees Fahrenheit (-18 degrees Celsius) or lower without shortening lamp life.

14. Ballasts are warranted for a minimum of five years. Ballast manufacturer provides replacement ballast, and pays all labor costs associated with replacing ballasts that fail during their warranty period.

15. Ballasts for T-5 standard and high output linear fluorescent lamps are manufactured by one of the following: Universal "Triad PRS", Osram/Sylvania "Quicktronic Professional PROStart", or Advance "Centium".

16. Ballasts for T-8 linear and U-bent fluorescent lamps be manufactured by one of the following: Universal "Accustart", Osram/Sylvania "Quicktronic Professional PROStart", or Advance "Mark V".

17. Ballasts for T-5 "biax" 2G11-base lamps (excluding NEMA FT40W) are manufactured by one of the following: Universal "Triad PRS" or Advance "Centium".

18. Ballasts for compact fluorescent lamps are manufactured by one of the following: Universal "Triad PRS", Osram/Sylvania "Quicktronic Professional CF Universal", or Advance "Smartmate".

D. Preheat electromagnetic compact fluorescent ballasts comply with the following:

1. Ballasts are encapsulated or potted to ensure maximum thermal and structural integrity.

2. Power factor is 0.90 or greater.

3. Ballast factor is between 0.95 and 1.05.

4. Ballasts are warranted for a minimum of two years. Ballast manufacturer provides replacement ballast and pays all labor costs associated with replacing ballasts that fail during their warranty period.

5. Ballasts are manufactured by Universal, Advance, or Robertson Worldwide.

E. Fluorescent dimming ballasts are solid-state electronic, providing smooth and continuous dimming over a minimum range of 100 percent light output to 1 percent light output unless connected to a daylight harvesting system. Ballasts connected to daylight harvesting systems dim lamps over a range of 100 percent light output to 10 percent light output. Dimming ballasts are endorsed by the manufacturer of the lighting control system to which they are connected. Unless otherwise noted, dimming ballasts are Lutron Hi-Lume or Lightolier PowerSpec HDF. Lutron ECO-10 ballasts area acceptable when connected to daylight harvesting systems.

F. Electromagnetic core and coil ballasts for HID lamps are combined with appropriate capacitors and starters, referred to collectively as ballast assemblies, for operation of specified lamps. Ballast assemblies comply with the following:

1. Ballast assemblies for HID lamps rated 100W or higher are constant-wattage autotransformer (CWA) type.

2. Ballast assemblies for HID lamps rated less than 100W are high-reactance autotransformer (HX-HPF) type.

3. Power factor is 0.90 or greater.

4. Ballast factor is 1.0.

5. Ballasts are designed in accordance with all applicable ANSI specifications, including ANSI C82.4.

6. Core and coil ballasts are designed with class "H" (180 degree Celsius) or higher insulation system and vacuum impregnated with resin.

7. Core and coil ballast and starter combinations are designed to provide reliable lamp starting down to negative 40 degrees Fahrenheit (negative 40 degrees Celsius) for High Pressure Sodium lamps and negative 20 degrees Fahrenheit (negative 30 degrees Celsius) for Metal Halide lamps.

8. Ignitors are designed to provide six months of lamp open circuit operation without failure.

9. Ballast assemblies are warranted for a minimum of two years. Manufacturer provides replacement ballast assembly, and pays all labor costs associated with replacing ballast assemblies that fail during their warranty period.

10. Ballasts are manufactured by Universal, Advance, Venture, or Robertson Worldwide.

G. Electronic ballasts for Metal Halide lamps comply with the following:

1. Ballasts operate from a 50/60 Hz input source of 108-305 volts with no damage to the ballasts.

2. Input current Total Harmonic Distortion (THD) does not exceed 15 percent.

3. Power factor is 0.90 or greater.

4. Ballast is thermally protected and incorporate lamp shutdown circuitry for end of lamp life protection.

5. Ballast factor is 1.0.

6. Ballasts operate lamps at a frequency of less than 200 Hz.

7. Ballasts comply with the Federal Communications Commission rules and regulations, Title 47 CFR Part 18 Non-Consumer Equipment for EMI (power line conducted) and RFI (radiated).

8. Ballasts have class "A" sound rating.

9. Lamp current crest factor is less than 1.5.

10. Ballasts are designed to provide reliable lamp starting down to negative 20 degrees Fahrenheit (negative 30 degrees Celsius).

11. Ballasts are warranted for a minimum of five years. Ballast manufacturer provides replacement ballast, and pays all labor costs associates with replacing ballasts that fail during their warranty period.

12. Ballasts are manufactured by one of the following: Aromat, or Advance "e-Vision".

H. Emergency battery packs (also known as emergency ballasts): An emergency battery pack incorporates a battery, charger, inverter circuit, and control electronics into one housing. Emergency battery packs comply with the following:

1. The emergency battery packs are designed to work in conjunction with the standard AC ballast in the fixture, and with an indicator light and test switch provided by the manufacturer of the battery pack.

2. Emergency battery packs are UL 924 Listed, and meet or exceed all National Electrical Code (NFPA-70) and Life Safety Code (NFPA-101) emergency lighting requirements.

3. Emergency battery packs incorporate maintenance-free Nickel-Cadmium (Ni-Cad) batteries.

4. Emergency battery packs are designed to provide a minimum of 90 minutes of emergency illumination. Provide longer duration when required by code.

5. Unless otherwise specified, emergency battery packs provide the following minimum initial lumen output per battery pack:

Lamp Type	Lumens
T-8, T-5	825
T-5 High Output	1,300
T-5 "biax" 2G11-base	825
Compact Fluorescent	650

6. Emergency battery packs are warranted for a minimum of five years. Manufacturer provides replacement emergency battery pack and pays all labor costs associated with replacing emergency battery packs that fail during their warranty period.

7. Emergency battery packs are manufactured by Iota Engineering or Bodine.

2.4 LAMPS

A. Conform to the ANSI C78 series that is applicable to each type of lamp.

B. Incandescent Lamps:

1. Unless otherwise noted, all 37W and 50W MR16 lamps are Osram/Sylvania "Tru-Aim IR". All other MR16 lamps are GE "Constant Color", Osram/Sylvania "Tru-Aim Titan", or Philips "Continuum Color" to insure consistent color. All MR16 lamps have an integral clear cover glass lens.

2. Unless otherwise noted, all 50W, 60W, and 100W PAR38 lamps, and all 50W PAR30 lamps incorporate "halogen infrared" technology, by the following manufacturers: GE "HIR", Philips "IRC", or Osram/Sylvania "IR".

C. Fluorescent lamps (T-8, T-5, and T-5 2G11-base):

1. Rated average life is a minimum of 20,000 hours when operated three hours per start. A shorter rated average life is acceptable for 50W and 55W T-5 2G11-base lamps only.

2. Unless otherwise noted, lamp phosphors are a composition that includes rare earth phosphors, with a correlated color temperature (CCT) of 3500 degrees Kelvin and a color rendering index (CRI) of not less than 80 (NEMA designation RE 835).

3. All T-8 linear fluorescent lamps are TCLP-compliant. Provide only GE "Ecolux", Philips "ALTO", or Osram/Sylvania "Ecologic" lamps.

D. Compact fluorescent lamps (T-4):

1. Rated average life is a minimum of 10,000 hours when operated at three hours per start.

2. Lamp phosphors are a composition that includes rare earth phosphors, with a correlated color temperature (CCT) of 3,000 degrees Kelvin and a color rendering index (CRI) of not less than 80 (NEMA designation RE 830).

3. T-4 "twin tube" compact fluorescent lamps rated 13W or lower (NEMA CFT13W, CFT9W, and CFT7W) have two-pin bases. Four-pin bases are required for all other compact fluorescent lamps.

E. Metal Halide Lamps:

1. Unless otherwise noted, all 20W, 39W, 50W, 70W, and 100W lamps incorporate ceramic arc tube technology. Provide only Philips "Mastercolor" or GE "CMH" lamps.

2. "Pulse Start" lamps, where specified, are combined with an appropriate ballast assembly to achieve manufacturer's rated performance.

3. Provide lamps with the highest color rendering index (CRI) available at the specified correlated color temperature (CCT). The minimum CRI for coated lamps is 70, and the minimum CRI for clear lamps is 65.

4. Provide "protected" or "open rated" lamps for use in all open fixtures.

F. All lamps are manufactured by GE, Osram/Sylvania, Philips, or Venture.

2.5 FINISHES

A. Provide metal finishes and paint colors as selected by the Architect.

B. Where a "Custom Color Finish" is specified but not identified, match sample provided by Architect.

C. Apply paint finishes over corrosion-resistant treatment or primer, free of streaks, runs, stains, blisters, and similar defects.

D. When the Architect issues no instructions pertaining to finishes, provide standard finishes as follows:

1. Unpainted non-reflecting surfaces are satin finished and coated with a baked-on clear lacquer to preserve the surface. Where aluminum surfaces are treated with an anodic process, the clear lacquer coating may be omitted.

2. Enamel coatings are of the high temperature baked-on type. Enamel reflecting surfaces are white with 90 percent minimum initial reflectance.

3. Porcelain enameled finishes meet or exceed R.L.M. standards in all respects.

4. Painted surfaces on fixtures for use outdoors or in damp locations exhibit weather and moisture resisting qualities equal to surfaces having epoxy based coatings. Unpainted aluminum are anodized.

5. Unpainted aluminum reflecting surfaces are treated with an Alzak or anodizing process to insure a permanent reflective surface with a minimum 87 percent reflectance.

2.6 EXIT SIGNS

A. Exit signs comply with the following:

1. Color, letter height, and letter stroke comply with all requirements of applicable state and local building codes.

2. Edge-lit exit signs which are visible from two directions have a mylar film inserted in the center of the panel, so that the letters are not visible from the wrong direction.

B. Self-illuminated exit signs equipped with integral battery packs for emergency operation comply with the following:

1. The battery is a sealed, maintenance-free nickel-cadmium battery with a five-year warranty.

2. The charger is solid-state, fully automatic with a sealed transfer relay.

3. When the input voltage drops to 80 percent of normal or below, the relay energizes the lamps from the battery pack, instead of the normal building power. When normal power is restored, the relay energizes the lamps from the normal building power, automatically recharge the battery, and float it on the charger.

2.7 LIGHTING CONTROLS

A. Lighting controls including - but not limited to - switches, occupancy sensors, photoelectric sensors, timeclocks, dimmers, relays, panels, and other miscellaneous devices are provided as part of the electric work.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set light fixtures plumb, square, and level with ceiling, walls, and/or ground and secure according to manufacturer's written instructions and approved Shop Drawings. Support fixtures according to requirements of Division 16 Section “Supporting Devices”

B. Fixtures suspended more than 48 inches (1200mm) below ceiling are braced to limit swinging.

C. When lamps are not specified, lamp units according to manufacturer's instructions.

D. Light fixture locations shown on electrical drawings are approximate. For light fixtures in building equipment rooms (Mechanical, Electrical, Telecommunications, etc.), coordinate fixture locations with equipment, so that optimal light distribution is obtained, without obstructing access to equipment. All other light fixtures are installed as shown on architectural drawings, or as directed by Architect.

E. Fixtures with asymmetric light distributions are oriented as shown in manufacturer's installation instructions. When manufacturer's instructions are not clear, obtain clarification from Architect before proceeding with installation.

3.2 CONNECTIONS

A. Ground light fixtures. Tighten electrical connectors and terminals, including grounding connections, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Verify normal operation of each fixture after fixtures have been installed and circuits have been energized with normal power source. Interrupt electrical power to demonstrate proper operation of emergency lighting.

C. Repair and retest malfunctioning fixtures and components. Repeat procedure until all units operate properly.

D. Replace fixtures that show evidence of corrosion during Project warranty period.

E. All permanent light fixtures used for temporary light during the construction phase for a period over 1,000 hours for fluorescent and HID sources and 100 hours for incandescent are relamped prior to acceptance.

3.4 ADJUSTING AND CLEANING

A. Clean fixtures after installation. Use methods and materials recommended by manufacturer.

B. Adjust aimable fixtures to provide required light intensities. Aim all adjustable fixtures after dark, under the direction of Lighting Consultant, Architect, or Engineer.

3.5 SPARES

A. Provide spare components to Owner at completion of project as outlined below:

1. For fluorescent, compact fluorescent, and HID lamps, provide one spare of each type for every ten installed (ten percent spare). Provide a minimum of four spare lamps of each type.

2. For incandescent lamps, provide one spare of each type for every five installed (twenty percent spare). Provide a minimum of four spare lamps of each type.

3. For ballasts and transformers, provide one spare of each type for every twenty installed (five percent spare). Provide a minimum of one spare of each type.

4. For interior lenses, louvers and diffusers, provide one spare of each type for every twenty-five installed (four percent spare). Provide a minimum of one spare of each type.

END OF SECTION 16500

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SECTION 16670 - LIGHTNING PROTECTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes lightning protection for buildings and associated structures and requirements for lightning protection system components.

1.3 SYSTEM DESCRIPTION

A. Protect entire building and outlying electro/mechanical equipment.

1.4 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each component specified.

C. Shop Drawings detailing lightning protection system. Include air terminal locations, conductor routing and connections, and bonding and grounding provisions. Include indications for use of raceway and data on how concealment requirements will be met.

D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by Nationally Recognized Testing Laboratory (NRTL) or trade association. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

E. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

F. Field inspection reports indicating compliance with specified requirements.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who is Underwriters Laboratories listed.

B. Listing and Labeling: Provide products specified in this Section that are Underwriters Laboratories listed and labeled.
   1. The Terms "Listed" and "Labeled": As defined in the National Electrical Code, Article 100.

C. Comply with NFPA 70, as amended by state and local codes.

D. Comply with NFPA 780.

E. Comply with UL 96 and UL 96A.

F. Provide UL Master Label to owner.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   1. Approved Lightning Protection Co., Inc.

   2. Harger Lightning Protection, Inc.

   3. Heary Bros. Lightning Protection Co.

   4. Thompson Lightning Protection Co.

2.2 LIGHTNING PROTECTION SYSTEM COMPONENTS

A. System Materials: Copper, with solid air terminals, except as otherwise indicated.

B. Air Terminals for Single-Ply Membrane Roof Mounting: Units with bases especially designed for single-ply membrane roof materials.

C. Ground Rods: Copper-clad steel with a minimum of 27 percent of rod weight in copper cladding.
   1. Diameter: 3/4 inch (19 mm).

   2. Length: 10 feet (3 m).

D. Arresters, Protectors and Antenna-Discharge Units: Comply with UL 1449.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces, areas, and conditions, with Installer present, for compliance with installation tolerances and other conditions affecting performance of lightning protection. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install lightning protection as indicated, according to manufacturer's written instructions.

B. Comply with UL 96A, and NFPA 780.

C. Conform to the most stringent requirements when more than one standard is specified.

D. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops. Where concealed, run conductors in nonmetallic raceway - Schedule 40 minimum.

E. Conceal system conductors.

F. Conceal conductors from normal view from exterior locations at grade within 200 feet (60 m) of building.

G. Provide notification at least 48 hours before concealing lightning protection components.

H. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

I. Air Terminals on Single-Ply Membrane Roofing: Comply with adhesive manufacturer's installation instructions.

J. Bond extremities of vertical metal bodies exceeding 60 feet (18 m) in length to lightning protection components.

K. Bond ground terminals to counterpoise conductor.

L. Bond grounded metal bodies on building within 12 feet (4 m) of ground to counterpoise conductor.

M. Bond grounded metal bodies on building within 12 feet (4 m) of roof to counterpoise conductor.

N. Bond grounded metal bodies on building within 12 feet (4 m) of roof to interconnecting loop at eave level or above.

O. Bond lightning protection components to grounded metal bodies on building at every

60 feet (18 m) with intermediate-level interconnection loop conductors.

P. Install lightning arresters, protectors and antenna discharge units on all incoming electrical and telecommunication services and antenna lead-ins.

3.3 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture, unless moisture is permanently excluded from the junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

3.4 FIELD QUALITY CONTROL

A. UL Inspection: Apply for inspection by UL as required for UL master labeling of system. Provide additional components as required to obtain UL Master Label at no additional cost to owner.

END OF SECTION 16670

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Telecommunications mounting elements.
2. Backboards.
3. Telecommunications equipment racks and cabinets.
4. Telecommunications service entrance pathways.
5. Grounding.

B. Related Sections:
1. Division 16 Section 16710 “Premise Distribution System.”
2. Division 16 Section 16716 "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
3. Division 16 Section 16717 "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

C. LAN: Local area network.

D. RCDD: Registered Communications Distribution Designer.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

D. Grounding: Comply with ANSI-J-STD-607-A.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.7 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, J-hooks, and D-rings.
4. Straps and other devices.

C. Cable Trays:
1. Refer to Section 16127 “Cable Trays” for specification information.

D. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways and Boxes." Flexible metal conduit shall not be used.
1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 6 Section "Rough Carpentry."

B. Provide prefabricated backboard as indicated on the drawings.

2.3 EQUIPMENT FRAMES

A. Manufacturers: Subject to compliance with requirements of paragraph 1.2 C of Section 16710, provide products by one of the following:
1. ADC.
2. Aim Electronics; a brand of Emerson Electric Co.
3. AMP; a Tyco International Ltd. company.
4. Cooper B-Line, Inc.
5. Hubbell Premise Wiring.
6. KRONE Incorporated.
7. Leviton Voice & Data Division.
8. Middle Atlantic Products, Inc.
9. Nordex/CDT; a subsidiary of Cable Design Technologies.
10. Ortronics, Inc.
11. Panduit Corp.
12. Siemon Co. (The).

B. General Frame Requirements:

1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Module Dimension: Width compatible with EIA 310 standard, 19-inch (480-mm) panel mounting.
3. Finish: Manufacturer's standard, baked-polyester powder coat.

C. Floor-Mounted Racks: Modular-type, steel or aluminum construction.
1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
2. Baked-polyester powder coat finish.

D. Modular Freestanding Cabinets:
1. Removable and lockable side panels.
2. Hinged and lockable front and rear doors.
3. Adjustable feet for leveling.
4. Screened ventilation openings in the roof and rear door.
5. Cable access provisions in the roof and base.
6. Grounding bus bar.
7. Rack-mounted, 550-cfm (260-L/s) fan with filter.
8. Power strip.
9. Baked-polyester powder coat finish.
10. All cabinets keyed alike.

E. Modular Wall Cabinets:
1. Wall mounting.
2. Steel or aluminum construction.
3. Treated to resist corrosion.
4. Lockable front and rear doors.
5. Louvered side panels.
6. Cable access provisions top and bottom.
7. Grounding lug.
8. Rack-mounted, 250-cfm (118-L/s) fan.
9. Power strip.
10. All cabinets keyed alike.

F. Cable Management for Equipment Frames:
1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.4 POWER STRIPS

A. Power Strips: Comply with UL 1363.
1. Rack mounting.
2. Six 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
3. LED indicator lights for power and protection status.
4. LED indicator lights for reverse polarity and open outlet ground.
5. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
6. Close-coupled, direct plug-in line cord.

7. Rocker-type on-off switch, illuminated when in on position.

2.5 GROUNDING

A. Comply with requirements in Division 16 Section "Grounding and Bonding" for grounding conductors and connectors.

B. Telecommunications Main Bus Bar:
1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
2. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Comply with ANSI-J-STD-607-A.

2.6 LABELING

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Install underground pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.
1. Install underground entrance pathway complying with Division 16 Section "Raceways and Boxes."

3.2 INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

C. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.3 FIRESTOPPING

A. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.4 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
   1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.5 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 16 Section "Electrical Identification."

B. Comply with requirements in Division 9 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 3 level of administration including optional identification requirements of this standard.

D. Labels shall be preprinted or computer-printed type.

END OF SECTION 16714

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Local Area Network Hardware.
2. Wireless Network.
3. Network Management.
4. Configuration.
5. Device and Cable Identification
6. System Warranty

1.3 FUNCTIONS AND PERFORMANCE REQUIREMENTS

A. Firewall: The new network design shall incorporate a firewall between the airport and the outside world. VPN access shall be created for remote access by the Owner and Integrator for testing and maintenance.

B. Pre-Configuration: Provide pre-configuration of all equipment before deploying it in the field.

C. Field Configuration: Provide addition field configuration of the network to provide optimized network services for all users.

D. Network Monitoring: A comprehensive on-site network monitoring system shall be put in place, which will ensure that all key services are functional. Further refinements shall track service degradation in other areas, provide enhanced alerting, and allow for long-term tracking of resource allocation. The network monitoring system shall monitor and manage the following critical systems:
1. UPS system.
2. Access Control Hardware.
3. CCTV Hardware.
4. Wireless Devices.
5. Temperature Sensors.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated on the drawings and specifications.

B. Shop Drawings: Provide complete shop drawings which include the following:
1. Indicate all system device locations on scaled plans.

2. Include full schematic wiring information on these drawings for all devices. Wiring information shall include cable type, conductor routings, quantities, and connection details at device.
3. Include a complete one-line, block diagram.
4. Include a statement of the system sequence of operation of each device and overall system performance.

C. Qualification Data: For Project Manager and network implementation engineers.

D. Software and Firmware Operational Documentation:
1. Software operating and upgrade manuals.
2. Device address list.
3. Printout of software application and graphic screens.

E. Wireless Network Report

F. Project Close-out Submittal:
1. Provide three sets of hard copy manuals and three sets electronic format manuals including operating instructions, maintenance recommendations and parts list including wiring and connection diagrams modified to reflect as-built conditions.
2. Final copies of the manuals shall be delivered within 30 days after completing the installation test. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of the contractor responsible for the installation and maintenance of the system and the factory representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The final copies delivered after completion of the installation test shall include all modifications made during installation, checkout, and acceptance testing. The manuals shall consist of the following
   a. Functional Design Manual: The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included.
   b. Hardware Manual: The manual shall describe all equipment furnished including:
      1) General description and specifications
      2) Installation and check out procedures
      3) Equipment layout and electrical schematics to the component level
      4) System layout drawings and schematics
      5) Alignment and calibration procedures
      6) Manufacturers repair parts list indicating sources of supply
   c. Software Manual: The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
      1) Definition of terms and functions
      2) System use and application software
      3) Initialization, start up, and shut down
      4) Reports generation
      5) Details on customization and field parameters
   d. Maintenance Manual: The maintenance manual shall include descriptions of maintenance for all equipment including inspection,

periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

3. As-Built Drawings: During system installation, the Contractor shall maintain a separate hard copy set of drawings, elementary diagrams, and wiring diagrams of the network to be used for record drawings. This set shall be accurately kept up to date by the Contractor with all changes and additions to the network. Copies of the final as-built drawings shall be provided to the end user in PDF format.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Test equipment upon receipt at Project site. Store and handle as required by manufacturer's instructions.

1.6 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1.7 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

B. One network switch, mesh node and antenna of each type complete to allow easy swapping of a defective switch without requirement of new software or firmware.

1.8 QUALIFICATIONS

A. The system contractor integrator responsible for providing the network shall have at least ten (10) years experience in furnishing and installation of such systems.

B. The system contractor's project manager and on-site superintendent shall have a minimum of fifteen (15) years experience and shall have worked on the projects in similar capacity.

C. Manufacturer Qualifications

1. Manufacturer of the network hardware shall be an established organization with referenced and documented experience delivering and maintaining network system of equal or higher sophistication and complexity as compared to the system detailed in this specification.
2. Manufacturer's manufacturing facilities shall be certified ISO-9000:2000 operations, utilize ISO-9000:2000 manufacturing procedures and maintain their ISO certifications.
3. Manufacturer shall employ at a minimum the following methods for QA of component and assembly devices.
   a. Visual inspection of devices shall be performed to verify assembly according to defined procedures. End of line operational tests

shall be performed to ensure product functionality has been correctly configured. A system burn-in period shall be utilized to screen for early life failures of electronic components.

4. Individual functionality and system level regression testing shall be performed to ensure compliance with product specifications. Single and multiple unit system tests shall be performed to mimic end-user installation configurations. Automated hardware and software testing shall be utilized to evaluate system performance under published operational loads and shall be compared to published system capabilities.

D. Network installer experience: The network system integrator / contractor shall have factory trained personnel from the approved manufacturer with a minimum of five (5) years experience in system integration and a minimum of two (2) years experience in the proposed network systems for this project. Submit names of the qualified personnel.

PART 2 - PRODUCTS

2.1 LOCAL AREA NETWORK (LAN)

A. Provide network switches and other network components as indicated on the drawings.

B. LAN hardware shall be Cisco or approved equal.

2.2 WIRELESS NETWORK (WIFI)

A. A site survey will be conducted prior to network design submission and results submitted with the design.

B. A wireless overlay shall be used to provide in-building roaming network connectivity. All access points shall provide 802.11 compatibility will full 54 Mbps connectivity available in 100% of all airport spaces.

C. WEP, SSID and LEAP configuration information shall be coordinated with Owner & A/E prior to final configuration.

D. Access Point Naming Conventions: AP Number-IDF # to which AP connects-Patch Panel Port #.

2.3 NETWORK CONFIGURATION AND TECHNOLOGY IMPLEMENTATION

A. Develop and provide complete and secure network configuration for all network users and devices as indicated on drawings.

B. The approved IT professional shall provide following services to provide an efficient secured and highly manageable network system:
1. Develop planning and implementation strategy, working with the owner, A/E and other network users, for the implementation of the network.
2. Develop LAN configuration including Quality of Service, Layer Switching and Forwarding, Multicast, Port Monitoring, Spanning Tree Protocol, VLAN Trunking Protocol and other techniques.

3. Develop Monitoring and Management procedures. Network monitoring system shall be configured to notify administrator of system modifications and provide a management policy for tracking and notification.
4. Develop Network Optimization scheme to prevent larger users of the network resources (e.g. CCTV system) from reducing network availability and efficiency. Develop QoS priorities and coordinate optimization with all systems connected to the network. Integrator shall notify A/E of any priority issues that cannot be resolved with network configurations.

2.4 IP ADDRESSING

A. IP addressing ranges shall be coordinated with Owner and A/E prior to implementation.

PART 3 - EXECUTION

3.1 IMPLEMENTATION

A. Provide a detailed implementation schedule, coordinated with all network users and devices, for review and approval.

B. Provide network services as required to meet phasing, sequencing and completion on schedule.

3.2 DELIVERABLES:

A. All deliverables will be provided electronically and in hard copy.
1. Electronic deliverables will be sent to the Peoria Airport Network Administrator and A/E.
2. Hard copy deliverables shall be placed in a heavy duty plastic pouch (preferred) or laminated.
3. Specific deliverables are dependent upon scope of work; however, an asset tracking spreadsheet shall be required.

3.3 ACCEPTANCE CRITERIA

A. All electronic deliverables have been received.

B. Successfully demonstrate network management and monitoring system.

C. Output of show interfaces command indicates that end user devices are communicating properly with network electronics. Obviously incrementing errors on an interface shall be resolved prior to acceptance.

D. Onsite inspection is conducted.
1. Packing material has been removed from all devices.
2. All equipment is properly secured and mounted.
3. Velcro has been used to secure power cords and patch cables.
4. Patch cables of proper color are neatly and properly contained in wire managers or properly dressed with Velcro if wire managers are not installed.
5. Power cords form hardware to power outlets are neatly attached.
6. Hard copy deliverables are in place.

7. Check of labeling configuration indicates accuracy of documentation.
8. Outdoor penetrations and cable connections are properly weather proofed.
9. Viewing reports of network monitoring systems.

3.4 MAINTENANCE SERVICES (WARRANTY)

A. The Contractor shall provide "on-call" warranty maintenance service for all equipment supplied under this Contract for two (2) years after acceptance of the entire NETWORK EQUIPMENT (hardware and software) by Owner. The “On Call” services shall be provided by the qualified contractor and shall include combination of periodic (once every 4 months for a minimum of two days) onsite and additional 24/7 support by remote (telephone and remote log-in) access. Include additional two (2) days per year for emergency services.

END OF SECTION 16715

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Pathways.
2. UTP cable.
3. Optical fiber cabling.
4. Coaxial cable.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Cabling identification products.

B. Related Sections:
1. Division 16 Section 16710 “Premise Distribution System.”
2. Division 16 Section 16714 “Communication Equipment Room Fittings.”
3. Division 16 Section 16717 “Communication Backbone Cabling.”

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.4 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated.
   1. For coaxial cable, UTP , and Optical Fiber cable include the following installation data for each type used:
      a. Nominal OD.
      b. Minimum bending radius.
      c. Maximum pulling tension.

B. Shop Drawings:
   1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
   2. Cabling administration drawings and printouts.
   3. Wiring diagrams to show typical wiring schematics including the following:
      a. Cross-connects.
      b. Patch panels.
      c. Patch cords.
   4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
   5. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
      a. Vertical and horizontal offsets and transitions.
      b. Clearances for access above and to side of cable trays.
      c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
      d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

D. Source quality-control reports.

E. Field quality-control reports.

F. Maintenance Data: For splices and connectors to include in maintenance manuals.

G. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.

3. Device address list.
4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings Cabling Administration Drawings, and field testing program development by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
   3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 450 or less.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

E. Grounding: Comply with ANSI-J-STD-607-A.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
   1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
   2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
   3. Test each pair of UTP cable for open and short circuits.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.11 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two (2) years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
   1. Provide thirty (30) days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.12 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Patch-Panel Units: One of each type.
   2. Connecting Blocks: One of each type.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
   1. Support brackets with cable tie slots for fastening cable ties to brackets.
   2. Lacing bars, spools, J-hooks, and D-rings.
   3. Straps and other devices.

C. Cable Trays:
   1. Refer to section 16127 for cable tray specifications

D. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways and Boxes." Flexible metal conduit shall not be used.

E. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 6 Section "Rough Carpentry" for plywood backing panels.

2.3 UTP CABLE

A. Manufacturers: Subject to compliance with requirements of paragraph 1.2 C of Section 16710, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Belden CDT Inc.; Electronics Division.
2. Berk-Tek; a Nexans company.
3. CommScope, Inc.
4. Mohawk; a division of Belden CDT.
5. Nordex/CDT; a subsidiary of Cable Design Technologies.
6. Superior Essex Inc.
7. SYSTIMAX Solutions; a CommScope Inc. brand.
8. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
9. or approved equal.

B. Description: 100-ohm, 100-pair or as shown on the drawings, UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket.
1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
   a. Communications, General Purpose: Type CM or CMG[;
   b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
   c. Communications, Riser Rated: Type CMR, complying with UL 1666.
   d. Communications, Limited Purpose: Type CMX.
   e. Multipurpose: Type MP.
   f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
   g. Multipurpose, Riser Rated: Type MPR complying with UL 1666.

2.4 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements of paragraph 1.2 C of Section 16710, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. American Technology Systems Industries, Inc.
2. Dynacom Corporation.
3. Hubbell Premise Wiring.
4. KRONE Incorporated.
5. Leviton Voice & Data Division.
6. Nordex/CDT; a subsidiary of Cable Design Technologies.
7. Panduit Corp.
8. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
9. or approved equal

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
   1. Number of Jacks per Field: One for each four-pair UTP cable indicated conductor group of indicated cables, plus 20% spares and blank positions adequate to suit specified expansion criteria.

E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

F. Patch Cords: Factory-made, 4-pair cables in 72-inch lengths; terminated with 8-position modular plug at each end.
   1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.

2.5 OPTICAL FIBER CABLE

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
   1. Sumitomo Air blown fiber system as shown on the drawings.
   2. Superior Essex.
   3. Allen Tel.
   4. Owens Corning.
   5. or approved equal.

B. Air Blown Fiber Installation (ABF)
   1. Furnish all labor, materials, tools and equipment to provide air blown fiber through compact cable infrastructure tubes. The air blown fiber equipment manufacture shall have at least 5 years of successful manufacturing of products with characteristics and capacities required by this section. All work shall comply with all applicable codes and standards.
   2. Provide rack and key lockable wall-mounted enclosures to terminate optical fibers from the air blown fiber bundles. The enclosures shall support and organize he fibers for termination. All accessories shall include, but are not limited to, breakout cables, tube couplings, plugs, caps and organizers. All couplings and caps shall be pressure rated to 200 psi.
   3. Install the system and all materials in accordance with manufacturer instructions.
   4. Provide all cable blowing heads and all equipment necessary for blowing the fiber in the tubes including any air or nitrogen gas required.
   5. All optical fibers shall be sufficiently free of surface imperfections and inclusions to meet the optical, mechanical and environmental requirements of this specification. All fibers in the fiber bundles must be usable.
   6. The fiber coating and buffer shall be removable with commercially available stripping tools without damaging the fiber.
   7. All fibers in the bundles shall meet industry standards on attenuation, bandwidth and dispersion specifications outlined below. Attenuation specification shall be a maximum attenuation for each fiber over the entire operating temperature range of the cable.

C. Multimode Fiber 62.5/125 micron:

1. The multimode fiber utilized in the cable specified herein shall meet TIA/EIA standards. The 62.5/125 micron grade-index multimode optical fiber shall be plenum or non-plenum rated as required and shall meet the following optical characteristics:

850 nm:	maximum attenuation	3.5 dB/km
	typical attenuation	3.0 dB/km
	minimum LED bandwidth	200 MHz•km
	minimum Gigabit distance	500 m
1300 nm	maximum attenuation	1.0 dB/km
	typical attenuation	1.0 dB/km
	minimum LED bandwidth	600 MHz•km
	minimum Gigabit distance	1000m

2. The multimode fiber utilized in the cable specified herein shall conform to the following specifications:

Fiber Core:	62.5/125 micron
Cladding Diameter:	62.5 ± 3 µm
Fiber Identification:	Individually color-coded per TIA/EIA standards
Operating Temperature	-22°F to 158°F

D. Multimode Fiber 50/125 micron

1. The multimode fiber utilized in the cable specified herein shall meet TIA/EIA standards. The 50/125 micron grade-index multimode optical fiber shall be plenum or non-plenum rated as required and shall meet the following optical characteristics:

850 nm:	maximum attenuation	3.0 dB/km
	minimum bandwidth	500 MHz•km
1300 nm	maximum attenuation	1.0 dB/km
	minimum bandwidth	500 MHz•km

2. The multimode fiber utilized in the cable specified herein shall conform to the following specifications:

Fiber Core:	50/125 micron
Cladding Diameter:	50 ± 3 µm
Fiber Identification:	Individually color-coded per TIA/EIA standards
Operating Temperature	-40°F to 158°F

E. Singlemode Fiber:

1. The singlemode fiber utilized in the cable specified herein shall meet TIA/EIA standards. The 8.3 micron singlemode optical fiber shall be plenum or non-plenum rated as required and shall meet the following optical characteristics:

1310 nm:	maximum attenuation	.40 dB/km
1550 nm	maximum attenuation	.30 dB/km

F. Outdoor Fiber Tubes

1. The multi-tube shall have a polyethylene outer jacket with a dry tape waterblocked cable core and meet TIA/EIA standards. The operating temperature range shall be -40°F to 158°F. The minimum bending radius shall be 20 cable diameters during installation and 10 cable diameters after installation.

G. Indoor Plenum Rated Fiber Tubes

1. The plenum rated multi-tube shall have a low smoke, flame resistant outer jacket and meet TIA/EIA standards. The operating temperature range shall be 32°F to 122°F. The minimum bending radius shall be 20 cable diameters during installation and 10 cable diameters after installation. UL 910 OFNP Rated.

H. Tube Distribution Equipment
1. Provide rack and key lockable wall-mounted enclosures to terminate optical fibers from the air blown fiber bundles. The enclosures shall support and organize the fibers for termination. Include all accessories including but are not limited to breakout cables, tube couplings, plugs, caps and organizers. All couplings and caps shall be pressure rated to 200 psi.

2.6 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements of paragraph 1.2 C of Section 16710, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. ADC.
2. American Technology Systems Industries, Inc.
3. Berk-Tek; a Nexans company.
4. Corning Cable Systems.
5. Dynacom Corporation.
6. Hubbell Premise Wiring.
7. Molex Premise Networks; a division of Molex, Inc.
8. Nordex/CDT; a subsidiary of Cable Design Technologies.
9. Optical Connectivity Solutions Division; Emerson Network Power.
10. Siemon Co. (The).

B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

C. Patch Cords: Factory-made, dual-fiber cables in 72-inch lengths.

D. Cable Connecting Hardware:
1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

E. Fiber SC Termination
1. The fiber building cable shall be terminated at the Fiber Interconnect cabinets, work area outlets and the communication equipment. The connector shall allow many reconnections with consistent repeatable performance.

F. Multimode
1. The only approved method of termination is the T568 SC multimode connector, manufacturer approved for the cable supplied. The connector shall be an approved component and meet the following requirements:

Mean Loss	0.3 dB
Standard Deviation	0.2 dB
Fiber OD	125 micron
Cable OD	3.0 mm
Loss Repeat	<0.3 dB, 200 insertions
Axial Load	30 lbs.
Temperature Stability	<0.3 dB Max. change

The connector shall consist of the following material:

Tip	Ceramic
Cap	Poly Sulfone

2. The connector shall be installed on the fiber utilizing an approved tool kit. This kit contains all tools and instructions to mount the connector quickly and easily, utilizing the Manufacturer's installation procedures.

G. Single-mode

1. The only approved method of termination is the T568 SC single-mode connector, manufacturer approved for the cable supplied. The connector shall be an approved component and meet the following requirements:

Mean Loss	0.2dB
Standard Deviation	0.1dB
Fiber OD	125 micron
Cable OD	3.0 mm
Loss Repeat	<0.2dB, 200 insertions
Axial Load	30 lbs.
Temperature Stability	<0.3 dB Max. change

The connector shall consist of the following material:

Tip	Zirconia Ceramic
Cap	Poly Sulfone

2. The connector shall be installed on the fiber utilizing an approved tool kit. This kit contains all tools and instructions to mount the connector quickly and easily, utilizing the Manufacturer's installation procedures.

2.7 FIBER JUMPER CABLES

A. Provide dual fiber FDDI grade fiber optic patch jumper assemblies for each fiber interconnect cabinet connector. Fiber cable shall be sized for the longest connection and installed in accordance with a schedule developed by the installation contractor. Fiber connectors shall match the fiber connector specifications. The patch cord fiber shall match the optical characteristics and specifications for the fiber cable specified and shall be covered by Aramid yarn and a jacket of flame-retardant PVC. The fiber patch cord shall meet the following specifications:

Minimum bend radius:	1.00 inch (2.54 cm)
Operating temperature:	-4°F to 158°F (-20°C to 70°C)
Mated connector loss:	0.4 dB
minimum bandwidth:	200MHz•km at 850nm, 500MHz•km at 1300nm
maximum attenuation	3.4 dB/km @ 850 nm, 1.0 dB/km @ 1300nm

ISO 9001 Certified Manufacturer

B. B. Multimode Fiber Patch Cord Specifications

Mated Connector Loss	μ = 0.3dB**,** s = 0.2dB
Operating temperature	-4°F to 158°F (-20°C to 70°C)
Cable Retention:	50 lb. (220 N) minimum
Connection Repeatability:	0.20 dB maximum changer per 100 reconnects

C. Single-mode Fiber Patch Cord Specifications

Return Loss:	-50 dB maximum
Mated connector loss	μ = 0.35 dB, s = 0.2dB
Cable Retention 50 lb.	(220 N) minimum
Connection Repeatability:	0.20 dB maximum changer per 200 reconnects

2.8 OPTICAL FIBER TELECOMMUNICATION OUTLETS

A. Provide fiber optical outlets with connectors as designated on the drawings or as required by the owner in single gang, dual gang, fiber optic and office furniture configurations. Provide recessed angled jacks to protect mating cables. Its modular design shall allow the adoption of interchangeable units for standard or customized voice, video, and data applications. The outlets shall include a decorative cover and all associated mounting hardware, modules, couplings, adapters and connectors. Submit color selection during submittal process, color to be determined after submittal. Covers shall come with recessed label space for circuit identifications.

B. All outlets shall be identified with clear permanent typewritten labels matching the numbering plan indicated on the drawings. Each module shall be labeled as to its current function using color-coded icons. All labeling must be permanent. All labeling shall be a minimum 12-point in size. All labeling systems shall be submitted to the owner's representative for approval prior to fabrication. Labeling shall last as long as the system is in use.

C. Provide a surface mounted enclosure that attaches directly over the standard electrical box provided.

D. Provide a means of securing the fiber cables while maintaining a minimum bend radius of 30 mm. This fiber ring shall store a minimum of 1 meter of two-count fiber.

2.9 OPTICAL FIBER CABLE INTERCONNECT CABINET

A. All fiber cables will be terminated at the telecommunication room sites in fiber interconnect cabinets. These cabinets will be wall or rack mounted, as designated on the drawings, or as required by the Owner. Rack mounted interconnect cabinets shall be placed at the top of the rack and located to minimize jumper distance to electronic equipment. Provide quantities and configurations as shown on the drawings. The fiber interconnect cabinet shall be a certified component and will directly terminate the fiber building cable.

B. Assure that the connectors for each cabling segment are installed in the correct orientation to ensure proper polarity of an optical fiber system from the main cross-connect to the telecommunications outlet/connector.

2.10 OPTICAL FIBER CABLE SPLICES & CLOSURES

A. Fiber Splicing: All fiber cable splicing shall be performed using the fusion splicing method unless the client specifically requires the mechanical method.

1. Fusion – The fiber splicer shall be fully automatic, calibrated and operate under the various jobsite environmental conditions (e.g. temperature, humidity, altitude, etc.) for all types of fiber cable being deployed.
   a. The mean splice loss for identical dispersion-unshifted singlemode fibers shall be equal to 0.05 dB at 1310 nm and 1550 nm wavelengths in accordance with CCITT G.652.
   b. The microprocessor controlled automatic positioning system shall control the fiber alignment, cleaning, gap-setting correlation of fiber positioning and fusing.
   c. The fusion splicer shall measure and document the splice losses of each splice. These measurements shall be saved and submitted to the TIPS Project Manager.
   d. Heat shrink protection shall be provided for each splice.
2. Mechanical – The fiber splice module shall meet the following specifications:
   a. Accept 250 and 900 micron fibers.
   b. Reenterable, rearrangable and reusable.
   c. Require no polishing.
   d. Require no adhesives.
   e. No loose parts.
   f. Mean splice loss 0.15 dB.
   g. Blind splice loss < 0.5 dB.
   h. One part index matching gel.
   i. Stable from -40°C to 75°C.

B. Splice Closures: The fiber splice canister closure shall seal, bond, anchor and protect fiber optic cable splices. The splice closure shall be re-enterable with a maximum of six (6) cable entries in a butt-end configuration. The cap shall be capable of accepting additional cables without disturbing existing splices. The slice closure shall be designed for application required i.e., aerial, underground and direct buried. It shall use corrosion free construction designed for splicing fibers. The unit shall include slack storage and the splice trays required or the specific project installation.

2.11 COAXIAL CABLE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Alpha Wire Company.
2. Belden CDT Inc.; Electronics Division.
3. Coleman Cable, Inc.
4. CommScope, Inc.
5. or approved equal.

B. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

C. RG-11/U: NFPA 70, Type CATV.
1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
4. Jacketed with sunlight-resistant, black PVC or PE.
5. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.

D. RG-6/U: NFPA 70, Type CATV or CMP
1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-foam fluorinated ethylene propylene insulation.
2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
3. Copolymer jacket.
4. Suitable for indoor installations.

E. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles.

2.12 COAXIAL CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Aim Electronics; a brand of Emerson Electric Co.
2. Leviton Voice & Data Division.
3. Siemon Co. (The).

B. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.13 GROUNDING

A. Comply with requirements in Division 16 Section "Grounding and Bonding" for grounding conductors and connectors.

B. Communication bonding and grounding shall be in accordance with the NEC, NFPA, NESC and ANSI/TIA/EIA Standard 607. Horizontal cables shall be grounded in compliance with ANSI/NFPA 70 and local requirements and practices. Horizontal equipment includes cross-connect frames, patch panels and racks, active telecommunication equipment and test apparatus and equipment.

C. #6 AWG stranded copper wire cable shall be extended between new ground bars located at each intermediate cross-connect and the building main service ground point. This ground conductor shall be utilized for equipment, termination, equipment rack and computer equipment grounding.

D. When the Telecommunications Rooms contains an electrical panel, provide a telecommunications ground utilizing a #6 AWG or larger bonding conductor that provides direct bonding between telecommunications rooms ground bar and

connected to the telecommunications room electrical panel Alternating Current Equipment Ground buss ACEG.

E. All outside plant installation metallic cable elements shall be grounded at the building entry points and at each splice location.

2.14 TELECOMMUNICATIONS BACKBOARD

A. Provide ¾ inch, 8-foot high, void-free, A/C grade plywood as designated on the drawings or as required by the owner. Paint the backboard with one prime coat and one finish coat of fire retardant pearl gray latex paint. Securely fasten the backboard to the wall to support the weight of the attached cable, termination and equipment.

2.15 ELEVATOR CONDUIT & CABLE

A. Provide a one-inch conduit from the telecommunication room to each elevator control room. The conduit shall originate in the vicinity of the 110 termination blocks and terminate in a 4 square telecommunication outlet box, with a voice jack, located as requested by the elevator contractor. Provide one Category 5e cable from the outlet box to the voice demarcation point.

2.16 FIRE ALARM CONDUIT & CABLE

A. Provide a one-inch conduit from the telecommunication room located closest to the fire alarm panel. The conduit shall originate in the vicinity of the 110 termination blocks and terminate in a 4 square telecommunication outlet box, with two voice jacks, located as requested by the fire alarm contractor. Provide two Category 5e cables from the outlet box to the voice demarcation point.

2.17 T1 TRANSMISSION

A. Provide outlets and circuit wiring for video teleconferencing over T1 transmission lines. The T1 service cable shall be run from the T1 outlet jack to the T1 demarcation outlets as required by the project. Each T1 demarcation outlet shall include a RJ48X miniature, non-keyed, 8-position 8-wire jack for each T1 outlet. Each T1 outlet shall include two ANSI/TIA/EIA-568-B 8-position Category 5e modular voice (telephone) jacks connected to a four pair UTP Category 6 cable and one RJ48X miniature. This T1 jack shall be non-keyed, 8-poistion 8-wire jack with shorting bars on pins 1 & 4 and 2 & 5, 110 type terminations shall be connected to a four pair UTP Category 5e cable.

2.18 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers. Use Panduit Ultimate ID Network Labeling System or equal.

2.19 SOURCE QUALITY CONTROL

A. Factory test cables on reels according to TIA/EIA-568-B.1.

B. Factory test UTP cables according to TIA/EIA-568-B.2.

C. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks. Conceal raceway and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways and Boxes."

B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 16 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 16 Section "Raceways and Boxes" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room from overhead.
   4. Extend conduits 3 inches (76 mm) above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

H. Air Blown Optical Fiber Cable: Install the system and all materials in accordance with manufacturer's instructions.
   1. Do not install the fiber until fiber tube cable system is complete
   2. Do not exceed manufacturer's maximum bending radius on tubes and fiber bundles.
   3. All spare strands shall be installed into spare splice trays, unless otherwise indicated on drawings.

3.4 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   1. Comply with TIA/EIA-568-B.1.
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
   7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
   8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
   10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
   11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
   1. Comply with TIA/EIA-568-B.2.
   2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:
   1. Comply with TIA/EIA-568-B.3.
   2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Outdoor Coaxial Cable Installation:
1. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
2. Attach antenna lead-in cable to support structure at intervals not exceeding 36 inches (915 mm).

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 FIRESTOPPING

A. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

B. Comply with TIA/EIA-569-A; Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.6 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.7 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 16 Section "Electrical Identification."
   1. Administration Class: 3.
   2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Division 9 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 3 level of administration including optional identification requirements of this standard.

D. Comply with requirements in Division 16 Section "Communications Horizontal Cabling" for cable and asset management software.

E. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and

workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

G. Cable and Wire Identification:
1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
   a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
   b. Label each unit and field within distribution racks and frames.
5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:

I. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Testing Requirements
1. Testing shall be performed after all components have been labeled and prior to system cutover. Test results shall meet or exceed manufacturer documentation data. All test equipment shall utilize the latest firmware and software recommended by the manufacturer. All test equipment shall be calibrated, tested and certified within one year of the commencement of the project testing. Otherwise, follow the manufacturer recommendations.
2. Telecommunications Bonding Backbone (TBB) Testing shall verify the integrity of all bonding connections and compliance to the NEC.
3. All cables and termination hardware shall be 100% tested for defects in installation and to verify cabling system performance under installed conditions according to the requirements of ANSI/TIA/EIA-568-B (B.1, B.2, and B.3). All pairs of each installed cable shall be verified prior to system acceptance. Any defect in the cabling system installation including but are not limited to cable, connectors, feed through couplers, patch panels, and connector blocks shall be repaired or replaced in order to ensure 100% usable conductors in all cables installed. All cables shall be tested in accordance with this document, the ANSI/TIA/EIA standards,

the manufacturer's requirements and BICSI Standards. If any of these are in conflict, the contractor shall bring any discrepancies to the attention of the project team for clarification and resolution. Verify proper grounding at service entrance and at all surge suppression devices.

C. Tests and Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
4. Optical Fiber Cable Tests:
   a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
   b. Link End-to-End Attenuation Tests:
      1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
      2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
   c. OTDR (Optical Time-Domain Reflectometer).
      1) Fiber testing shall be performed on all fibers in the completed end to end system.
      2) Testing shall consist of a bidirectional end to end OTDR trace performed per TIA/EIA 455-61. The system loss measurements shall be provided at 850 and 1300 nanometers for multimode fibers and 1310 and 1550 for single mode fibers. The OTDR shall be used only to determine the length and the attenuation of that cable. A power meter shall be used to determine the overall link attenuation, including connectors.
      3) Any link not meeting the requirements of the standard shall be brought into compliance by the Contractor, at no charge to the Owner.
      4) Provide both hard copy and PDF copy on CD-ROM to the A/E for approval.

D. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in

BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

F. End-to-end cabling will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.9 SYSTEM ACCEPTANCE

A. Upon completion of the aforementioned tests and before system acceptance, sample system operations shall also be performed with contractor provided test equipment and documentation to verify that the system is operational and ready for acceptance. Testing shall be performed on a sample basis (10% of installed outlets) on various portions of the network as determined by the A/E. The test shall be performed by the contractor, and witnessed by the A/E or owner's representative.

END OF SECTION 16716

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
1. Pathways.
2. UTP cabling.
3. Multi-user telecommunications outlet assemblies.
4. Cable connecting hardware, patch panels, and cross-connects.
5. Telecommunications outlet/connectors.
6. Cabling system identification products.
7. Cable management system.

B. Related Sections:
1. Division 16 Section 16710 “Premise Distribution System.”
2. Division 16 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
3. Division 16 Section "Communication Equipment Room fittings" for voice and data cabling systems.

1.3 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

G. LAN: Local area network.

H. MUTOA: Multi-user telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.

I. Outlet / Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

J. RCDD: Registered Communications Distribution Designer.

K. UTP: Unshielded twisted pair.

1.4 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.
   1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet / connectors be installed for each work area.
   2. Horizontal cabling shall contain no more that one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet / connector.
   3. Bridged taps and splices shall not be installed in the horizontal cabling.
   4. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.

1.5 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings:
   1. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
   2. Cabling administration drawings and printouts.
   3. Wiring diagrams to show typical wiring schematics, including the following:
      a. Cross-connects.
      b. Patch panels.
      c. Patch cords.
   4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.

5. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
   a. Vertical and horizontal offsets and transitions.
   b. Clearances for access above and to side of cable trays.
   c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
   d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration and faceplates for color selection and evaluation of technical features.

D. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

E. Source quality-control reports.

F. Field quality-control reports.

G. Maintenance Data: For splices and connectors to include in maintenance manuals.

H. Software and Firmware Operational Documentation:
   1. Software operating and upgrade manuals.
   2. Program Software Backup: On magnetic media or compact disk, complete with data files.
   3. Device address list.
   4. Printout of software application and graphic screens.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
   1. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD.
   2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician who shall be present at all times when Work of this Section is performed at Project site.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
   1. Flame-Spread Index: 25 or less.
   2. Smoke-Developed Index: 450 or less.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

E. Grounding: Comply with ANSI-J-STD-607-A.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.
1. Test each pair of UTP cable for open and short circuits.

1.9 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.11 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for two (2) years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
1. Provide thirty (30) days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.12 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Patch-Panel Units: One of each type.
2. Connecting Blocks: One of each type.
3. Device Plates: 10 of each type.
4. Multi-user Telecommunications Outlet Assemblies: 10 of each type.

PART 2 - PRODUCTS

2.1 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

C. Cable Trays: See specification section 16127

D. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways and Boxes." Flexible metal conduit shall not be used.
   1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements in Division 6 Section "Rough Carpentry" for plywood backing panels.

2.3 UTP CABLE

A. Manufacturers: Subject to compliance with requirements of paragraph 1.2 C., Section 16710, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Belden CDT Inc.; Electronics Division.
   2. Berk-Tek; a Nexans company.
   3. CommScope, Inc.
   4. Genesis Cable Products; Honeywell International, Inc.
   5. KRONE Incorporated.
   6. Mohawk; a division of Belden CDT.
   7. Nordex/CDT; a subsidiary of Cable Design Technologies.
   8. Superior Essex Inc.
   9. SYSTIMAX Solutions; a CommScope, Inc. brand.
   10. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
   11. Or approved equal.

B. Horizontal Wiring: Provide plenum rated 100 Ohm Unshielded Twisted Pair (UTP) cable with the following physical characteristics:
   1. The diameter of the insulated conductor shall be .048 in. maximum and shall consist of (4) 22 to 24 AWG twisted pairs.
   2. Shall be suitable for the environment in which they are to be installed. For Plenum, shall meet applicable requirements of ANSI/ICEA S-80-576. All four pairs must be insulated with F.E.P. No 2x2 or 3x1 construction will be allowed. Plenum rated cable shall be UL certified to conform to UL 910, CMP and shall be marked as such. Riser rated cable shall be third party certified to conform to UL 1666, CMR, CMG and IEC 332-1 and shall be marked as such.
   3. The color-coding of pairs shall be:
      a. Pair 1 W-BL; BL
      b. Pair 2 W-O; O
      c. Pair 3 W-G; G
      d. Pair 4 W-BR;BR

C. Horizontal Category 6 Wiring: Provide high speed data cabling conforming to ANSI/TIA/EIA 568-B.3 Category 6. All Category 6 cables shall conform to ANSI/TIA/EIA 568-B Commercial Building Telecommunications Cabling

Standard. Applications standards supported should include, but are not limited to, IEEE 802.3, 10BaseT-T, IEEE 802.5, 4 Mbps, 16 Mbps, 100 Base-T and 155 Mbps ATM1, 1000BaseT Gbps Ethernet, potentially 1.2 Gbps ATM and 2.4 Gbps ATM, Multitasked Split Screen Computing, Virtual Holographic Video Conferencing, 3D CAD/CAM Engineering, Internet-Intranet Communications / Commerce, as well as all 77 channels (550 MHz) of analog broad band video.

1. From each jack location there will be one sheath of plenum rated Inside Wiring Cable to the associated distribution frame.
2. The plenum cable shall be composed of 22 to 24 AWG bare solid copper conductors each with an insulation of Teflon. The insulated conductors are tightly twisted into pairs and jacketed with white low smoke PVC. It shall conform to a UL Type CMP listing for plenum and riser applications.
3. Each sheath shall contain four unshielded copper pairs. Each pair shall have a different twist ratio per foot.
4. The cables shall meet or exceed the following standards:
   a. ANSI/TIA/EIA 568-B “Commercial Building Wiring Standard
   b. UL listed
   c. National Electrical Code – Article 800
5. The cables shall meet the following representative electrical and transmission characteristics:

Frequency	Insertion loss	Pair to Pair	Power Sum	ELFEXT	SRL	Power Sum ELFEXT
MHz	cB/100m	NEXT dB	NEXT dB	DB	dB	dB
1.	2.0	74.3	72.3	67.8	20	64.8
4.	3.8	65.3	63.3	55.8	23	52.8
10.	6.0	59.3	57.3	47.8	25	44.8
16.	7.6	56.2	54.2	43.7	25	40.7
20.	8.5	54.8	52.8	41.8	25	38.8
25.	9.5	53.3	51.3	39.8	24.3	36.8
31.25	10.7	51.9	49.9	37.9	23.6	34.9
62.5	15.4	47.4	45.4	31.9	21.5	28.9
100	19.8	44.3	42.3	27.8	20.1	24.8
200	29.3	39.8	37.8	21.8	18	18.8
250.	32.8	38.3	36.3	19.8	17.3	16.8

6. Cable Manufacturer shall be ISO-9001 certified.
7. The cable packaging shall be constructed so as to prevent kinking and other damage to the cable during shipping and handling. All damaged cable will be replaced.

D. 25 Pair High Speed Data Tie Cable: Provide high speed data cabling conforming to ANSE/TIA/EIA 568-B Category 5e. All cables shall meet applicable requirements of ANSI/ICEA S-80-576. All Category 5e cables shall conform to ANSI/TIA/EIA 568-B Commercial Building Telecommunications Cabling Standard, Horizontal Cable Section. Applications standards supported should include, but are not limited to, IEEE 802.3, 10BaseT-T, IEEE 802.5, 4 Mbps, 16 Mbps and TP-PMD. In addition, these cables shall be capable of supporting evolving high-end applications such as 100 Base-T and 52/155 Mbps ATM.

1. The cable shall be composed of 22 to 24 AWG bare solid copper conductors with a suitable plastic dielectric material.

2. Each cable shall contain 25 unshielded copper pairs. Installed in tight sub-units to meet power sum Near End Crosstalk, swept Insertion loss and SRL requirements. The insulated conductors shall be twisted into pairs and stranded into mini-units. The cable shall employ a honeycomb core construction, consisting of multiple three and four pair tightly stranded sub-units. A total of seven unjacketed sub-units will be stranded to comprise the cable core.
3. The cables shall meet or exceed the following standards:
   a. ANSI/TIA/EIA 568-B "Commercial Building Wiring Standard," Category 5e Backbone
   b. Cable Section
   c. Certified Category 5e Cable under UL's LAN Cable Certification Program
   d. UL Listed CMR or CMP as required, UL Verified Cat 5e
   e. National Electrical Code – Article 800
4. The cables shall meet the TIA/EIA electrical and transmission characteristics.

a.	Outside Diameter	.48 inches
b.	Mutual Capacitance	5.6 nF/100m
c.	Impedance Z	100 ± 15% Ohms from 1-100 MHZ
d.	DC Resistance – Max.	9.38 Ohms/100 m

5. Cable Manufacturer shall be ISO-9001 certified.
6. The cable packaging shall be constructed so as to prevent kinking and other damage to the cable during shipping and handling. All damaged cable will be replaced.

2.4 UTP CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements of paragraph 1.2 C of Section 16710, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. American Technology Systems Industries, Inc.
   2. Dynacom Corporation.
   3. Hubbell Premise Wiring.
   4. KRONE Incorporated.
   5. Leviton Voice & Data Division.
   6. Molex Premise Networks; a division of Molex, Inc.
   7. Nordex/CDT; a subsidiary of Cable Design Technologies.
   8. Panduit Corp.
   9. Tyco Electronics/AMP Netconnect; Tyco International Ltd.
   10. or approved equal.

B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

C. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP cable indicated, plus 20% spares and blank positions adequate to suit specified expansion criteria.

E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

F. Patch Cords: Factory-made, four-pair cables in 72-inch lengths; terminated with eight-position modular plug at each end.
   1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.

2.5 CONSOLIDATION POINTS

A. Manufacturers: Subject to compliance with requirements of paragraph 12. C of Section 16710, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. American Technology Systems Industries, Inc.
   2. Chatsworth Products, Inc.
   3. Dynacom Corporation.
   4. Hubbell Premise Wiring.
   5. Molex Premise Networks; a division of Molex, Inc.
   6. Nordex/CDT; a subsidiary of Cable Design Technologies.
   7. Ortronics, Inc.
   8. Panduit Corp.
   9. Siemon Co. (The).
   10. Or approved equal.

B. Description: Consolidation points shall comply with requirements for cable connecting hardware.
   1. Number of Terminals per Field: One for each conductor in assigned cables.
   2. Number of Connectors per Field:
      a. One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
   3. Mounting: Recessed in ceiling, wall, desk or furniture as shown on drawings.
   4. NRTL listed as complying with UL 50 and UL 1863.
   5. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.

2.6 MULTIUSER TELECOMMUNICATIONS OUTLET ASSEMBLY (MUTOA)

A. Manufacturers: Subject to compliance with requirements of paragraph 12. C of Section 16710 , available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
   1. Chatsworth Products, Inc.
   2. Hubbell Premise Wiring.
   3. Molex Premise Networks; a division of Molex, Inc.
   4. Nordex/CDT; a subsidiary of Cable Design Technologies.
   5. Ortronics, Inc.
   6. Panduit Corp.

B. Modular Category 6 Jacks: The category 6 jack shall meet or exceed the following standards:

C. ANSI/TIA/EIA 568-B “Commercial Building Wiring Standard”.

D. FCC Part 68, Subpart “F”
1. The Category 6 modular jacks shall meet the following physical requirements:
2. Connector-insulation displacement connectors accepting 22 and 24 gauge AWG solid conductor wire
3. Jack wires-square copper alloy wires with 50 micro-inch lubricated gold plating over 100 micro-inch nickel plate
4. High impact, flame retardant UL-rated 94V-O thermoplastic
5. The Category 6 modular jacks shall meet the following mechanical requirements:
   a. Plug insertion life – minimum 750 plug insertions
   b. Contact Force – 100 grams minimum using FCC-approved modular plugs
   c. Plug Retention Force –(133N) minimum between modular plug and jack
   d. Temperature Range - -40° to 66°C
6. The outlet shall be approved to work in all applications up to 250 MHz, including, but are not limited to 1000BaseT Gigabit Ethernet.

Frequency	Insertion loss	Pair to Pair	FEXT dB	SRL
MHz	dB/100 m	NEXT dB	dB/100 m	dB
		dB/100 m		dB/100 m
1.	.1	75	75	19.8
4.	.1	75	71.1	21.6
10.	.1	74	63.1	22.8
16.	.1	69.9	59	23.4
20.	.1	68	57.1	23.7
25.	.1	66	55.1	24
31.25	.11	64.1	53.2	23
62.5	.16	58.1	47.2	20
100	.2	54	43.1	18
200	.28	48	37.1	15
250	.32	46	35.1	14

2.7 HIGH SPEED CATEGORY 6 DATA CROSS-CONNECT PATCH PANELS

A. The data patch panels will be co-located on 19-inch racks with the network hubs and the fiber optical interconnection cabinets as designated on the drawings or as required by the owner. The configuration of the patch panels shall be in an arrangement that minimizes patch cord lengths.

B. The modular patch panels shall have eight wires, 8-position modular jacks with 110 terminations on the rear for connection of station cables. The horizontal Category 6 cables to the outlets will be directly connected to 110 insulation displacement hardware associated with each jack on the patch panel. These panels will be designed to operate at 100/250 MHz. Quantities sufficient for all positions of every outlet are required.

C. The patch panel shall be a Category 6 modular jack panel with the following characteristic:
   1. The patch panel will utilize a 110 insulation displacement connector field on the back of the panel to terminate the horizontal cables. The 110 field is to remain continuous to the 8-pin modular jack field in the front of the panel.
   2. The cross-connect patch panel shall meet the following standards: ANSI/TIA/EIA 568-B “Commercial Building Wiring Standard FCC Part 68, Subpart F.

D. The Cross-connect patch panel shall meet the following physical requirements:
   1. Wire termination – insulation displacement, gas tight, slotted beam contact
   2. Plug contact force – 100 grams
   3. Plug retention force – 133 Newtons

E. The cross-connect patch panel shall meet the following environmental requirements:
   1. Operating Environment
      Temperature: 32°F to 140°F (0° to 60°C)
      Humidity: 5% to 95% (noncondensing)
   2. Storage Environment
      Temperature -40°F to 150°F (-40° to 66°C)
      Humidity: 5% to 95% (noncondensing)

F. The Category 6 panels shall be approved to work in all applications up to 250 MHz, including, but are not limited to, 1000BaseT Gigabit Ethernet.

G. The Category 6 panels shall meet or exceed the following representative electrical and transmission characteristics:

Frequency	Insertion loss	Pair to Pair	FEXT dB	SRL
MHz	dB/100 m	NEXT dB	dB/100 m	dB
		dB/100 m		dB/100 m
1.	.1	75	75	30
4.	.1	75	71.1	30
10.	.1	74	63.1	30
16.	.1	69.9	59	30
20.	.1	68	57.1	30
25.	.1	66	55.1	30
31.25	.11	64.1	53.2	30
62.5	.16	58.1	47.2	28.1
100	.2	54	43.1	24
200	.28	48	37.1	18
250	.32	46	35.1	16

H. Category 5e/6 Modular Patch Cords
   1. Provide 100% factory assembled and tested Category 6 plug-end cross-connecting patch cables for each modular patch panel jack. Cable shall be sized for the longest cross-connect and installed in accordance with a schedule developed by the installation contractor. The length of the patch

cable or cross-connect jumpers shall not exceed 20 feet. Provide color-coded boot assemblies to match owner's requirements.

2.8 GROUNDING

A. Comply with requirements in Division 16 Section "Grounding and Bonding" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.9 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers. Use Penduit Ultimate 10 Network Labeling system or equal.

B. Comply with requirements in Division 16 Section "Electrical Identification."

2.10 CABLE MANAGEMENT SYSTEM

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide comparable product by one of the following:
1. iTRACS Corporation.
2. Telsoft Solutions.
3. Or approved equal.

C. Description: Computer-based cable management system, with integrated database and graphic capabilities.

D. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.

E. Information shall be presented in database view, schematic plans, or technical drawings.
1. AutoCAD drawing software shall be used as drawing and schematic plans software.

F. System shall interface with the following testing and recording devices:
1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

2.11 SOURCE QUALITY CONTROL

A. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.

B. Factory test UTP cables according to TIA/EIA-568-B.2.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
   1. Install plenum cable in environmental air spaces, including plenum ceilings.
   2. Comply with requirements for raceways and boxes specified in Division 16 Section "Raceways and Boxes."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.2 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 16 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 16 Section "Raceways and Boxes" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:
   1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
   2. Install cable trays to route cables if conduits cannot be located in these positions.
   3. Secure conduits to backboard when entering room from overhead.
   4. Extend conduits 3 inches (76 mm) above finished floor.
   5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.3 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:
   1. Comply with TIA/EIA-568-B.1.
   2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
   3. Install 110-style IDC termination hardware unless otherwise indicated.
   4. MUTOA shall not be used as a cross-connect point.
   5. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
      a. Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      b. Locate consolidation points for UTP at least 49 feet (15 m) from communications equipment room.
   6. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
   7. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
   8. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
   9. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
   10. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
   11. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
   12. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
   13. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:
   1. Comply with TIA/EIA-568-B.2.
   2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:
   1. Comply with TIA/EIA-568-B.3.
   2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:
1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:
1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).
3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).
4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).
5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.4 FIRESTOPPING

A. Comply with requirements in Division 7 Section "Through-Penetration Firestop Systems."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.5 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.6 IDENTIFICATION

A. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

B. Comply with requirements in Division 9 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 3 level of administration, including optional identification requirements of this standard.

D. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

E. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.

F. Cable and Wire Identification:
   1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
   2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
   3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
   4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
      a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
      b. Label each unit and field within distribution racks and frames.
   5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
   6. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
   1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:
   1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
   2. Visually confirm Category 6, marking of outlets, cover plates, outlet / connectors, and patch panels.
   3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

C. UTP Performance Tests:
   1. Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
      a. Wire map.
      b. Length (physical vs. electrical, and length requirements).
      c. Insertion loss.
      d. Near-end crosstalk (NEXT) loss.
      e. Power sum near-end crosstalk (PSNEXT) loss.
      f. Equal-level far-end crosstalk (ELFEXT).
      g. Power sum equal-level far-end crosstalk (PSELFEXT).

h. Return loss.
i. Propagation delay.
j. Delay skew.

2. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
   a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
   b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

D. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets. Include training in cabling administration software.

END OF SECTION 16717

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This section includes a Fire Protective Alarm (FPA) system of the addressable initiating device type, consisting essentially of the following components:

1. Central equipment (also referred to as head end equipment) including Fire Command Station (FCS).

2. A graphic annunciator.

3. Outlying analog-addressable smoke (and smoke-heat) sensor/detectors.

4. Outlying addressable manual fire alarm stations.

5. Outlying addressable heat detectors.

6. Outlying sprinkler and fire standpipe alarm and supervisory devices furnished and installed separate from the work of this section.

7. Outlying addressable modules (monitoring or control) in addressable module boxes or cabinets.

8. Outlying loudspeaker stations; each with integrally mounted visual fire warning (strobe) except as otherwise specified.

9. Outlying visual warning signals (strobes).

10. Outlying intercom stations (floor warden stations).

11. Outlying "area of rescue assistance" intercom stations.

12. Outlying annunciator(s).

13. Outlying system equipment control cabinets (also referred to as equipment control cabinets).

14. Central damper control panel.

15. Interfaces with pre-action sprinkler systems, clean agent systems, or other standalone sub-systems.

16. Printer.

17. Interconnecting circuitry and control circuit extensions (i.e., final connections to controlled equipment from addressable module boxes).

B. Related Sections: The following Sections contain requirements that relate to this Section:

1. Division 15 Section "Electric-Drive, Horizontal Fire Pumps" for coordinating fire alarm system interconnections.

2. Division 15 Section "Standpipes and Hoses" for coordinating flow, pressure, and valve tamper switch requirements.

3. Division 15 Section "Pre-action Sprinkler System" for coordinating fire alarm system interconnections.

1.3 DEFINITION

A. FCS: Fire Command Station. Used interchangeably with FACP (see below)

B. FACP: Fire Alarm Control Panel (see above).

1.4 SYSTEM DESCRIPTION

A. General: Zoned, noncoded, addressable, microprocessor-based fire-detection and alarm system with manual and automatic alarm initiation, analog addressable smoke detectors, and automatic alarm verification for alarms initiated by certain smoke detector zones as indicated.

B. Signal Transmission: Multiplex signal transmission dedicated to fire alarm service only.

C. Audible Alarm Notification: By sounding of "alert" tone signals followed by voice messages, followed by "alarm" signals for zones as described hereinafter.

D. Visual Alarm Notification: By xenon-strobe-type units.

1.5 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections.

B. Product Data for each type of system component specified including dimensioned plans and elevations showing minimum clearances and installed features and devices. Include list of materials and Underwriters Laboratories and Factory Mutual listing data.

C. Shop Drawings showing details of graphic annunciator.

D. Wiring diagrams from manufacturer differentiating clearly between factory- and field-installed wiring. Include diagrams for equipment and for system with all terminals and interconnections identified. Make all diagrams specific to this Project and distinguish between field and factory wiring.

E. Device Address List: Coordinate with final system programming.

F. System operation description covering this specific Project, including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and outputs. Manufacturer's standard descriptions for generic systems are unacceptable.

G. Operating instructions for mounting at the FACP (FCS).

H. Product certificates signed by manufacturers of fire alarm system components certifying that their products comply with specified requirements.

I. Maintenance data for fire alarm systems to include in the operation and maintenance manual specified in Division 1. Include data for each type of product, including all features and operating sequences, both automatic and manual. Include recommendations for spare parts to be stocked at the site. Provide the names, addresses, and telephone numbers of service organizations that carry stock of repair parts for the system furnished.

J. In addition to routine submission of above materials, make all filings with the Building Department, Fire Department, and any other agencies having jurisdiction. Where filings require the engineer's signature, documents will be submitted for his review and signature. This responsibility will include furnishing of required quantities of floor plans, descriptive notes and/or specifications, wiring diagrams, shop drawings and amendment forms, as well as the payment of any required filing fees.

K. Permits necessary for installation of the work will be obtained prior to the commencement of the work. All permit costs and inspection fees will be included as part of the required work.

L. Record of field tests of system.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Installing contractor has at least 5 years experience in the installation of multiplexed fire alarm systems. Provide services of a NICET Level IV technician supplied by the fire alarm system manufacturer to supervise installation, adjustments and tests of system.

B. Single-Source Responsibility: Obtain fire alarm components from a single source who assumes responsibility for compatibility of system components.

C. Compliance with Local Requirements: Comply with the applicable building code, local ordinances, and regulations, and the requirements of the authorities having jurisdiction.

D. Comply with NFPA 70 as amended by state and local codes.

E. Comply with NFPA 72.

F. Comply with Americans with Disabilities Act (ADA).

G. Listing and Labeling: Provide fire alarm systems and components specified in this Section that are listed and labeled by Factory Mutual and Underwriters Laboratories.

H. The system is complete with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications will be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.

I. Early completion of the Fire Protective Alarm system will be required so as to permit a certificate of occupancy to be obtained in a timely manner, in accordance with a schedule established by the Architect.

J. Upon completion of the installation (and as directed by the Architect), the work includes making all arrangements and providing any assistance necessary for inspection and test as required for approval by the Fire Department. Modifications, adjustments and/or corrective work necessary to obtain approval along with subsequent inspection and test resulting from the issuance of a "Notice of Defect" will precede any consideration of formal acceptance by the Architect. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system also forms a part of the required work.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:

1. Edwards Systems Technology; General Signal Unit.

2. Simplex Fire Alarm, Inc.

3. Firecom, Inc.

4. Siemens Building Technologies, Inc.

2.2 FUNCTIONAL DESCRIPTION OF SYSTEM

A. Include system functions and operating features as described below, plus those additional functions and features required by the authorities having jurisdiction. System design is such that neither the failure of the normal power source, the transfer to an emergency source, nor the retransfer to the normal source causes a change in system status (i.e., initiation of alarm signals or operation of equipment control relays).

B. The central equipment of the system incorporates redundant components so that the failure of any component does not interfere with system operation as described hereinafter. Submission of the system for approval includes a detailed description of how compliance with this requirement is accomplished.

C. System supervision is such that the ability of all addressable alarm initiating devices and addressable modules to communicate with the central equipment is constantly monitored, and such failure results in an audible signal at the Fire Command Station (FCS) and outlying annunciator(s) and a visual annunciation identifying the faulted device or module.

D. The system utilizes a cathode ray tube (CRT) for the display of all required alarm and equipment status information, and an associated keyboard to permit manual access to the system. For fire department use, selector switch and pilot light modules are also included at the Fire Command Station for status and manual access to fans and dampers. A liquid crystal display (LCD) or electro-luminescent display capable of displaying at least 20 lines, with 80 characters per line, will be considered acceptable as an alternate to the CRT. System response time is such that alarm indications are displayed within 10 seconds of occurrence. No portion of the "executive" program is stored on magnetic media. It is entered into the system by means of "firmware."

E. Smoke detection devices (variously identified herein as "smoke detectors," "smoke sensors" and "smoke sensor/detectors") are understood to be of the <u>analog addressable smoke sensor type</u>, for which the decision to initiate an alarm in response to the presence of smoke is software-driven from the fire protective alarm system central equipment. Provisions are incorporated at the central equipment to manually test and/or adjust the sensitivity of each smoke detector individually by means of a keyboard or keypad without requiring any replacement of equipment and/or "burning in" of firmware, and to print out a record thereof. The system also incorporates "alarm verification" features enabling a time-delayed re-check of any smoke detection signal prior to acknowledging a smoke alarm condition and acting thereon.

F. Circuitry for the system complies with the following:

1. Circuits are of the following types:

(a) Signaling line circuits (SLC's) are utilized for the transmission of multiple signals from outlying addressable initiating devices, addressable control modules and addressable monitoring modules.

(b) "Trunk" signaling line circuits are SLC's originating directly from the system head-end equipment.

(c) "Branch" signaling line circuits are SLC's which are tapped off the "trunk" SLC's. Such circuits originate at outlying system equipment control cabinets, and are intended for the direct connection of outlying addressable initiating devices and/or modules.

(d) Initiating device circuits (IDC's) are utilized for the connection of non-addressable devices (such as sprinkler water flow switches) to their associated addressable modules.

(e) Notification appliance circuits (NAC's) are utilized for the connection of outlying alarm notification devices as follows:

(1) "Audible" NAC's are intended for the connection of loudspeakers.

(2) "Visual" NAC's are intended for the connection of strobes.

2. Trunk" SLC's comply with the following:

(a) They are NFPA 72, Style 7 (Modified) incorporating isolators to limit the loss of signal transmission in the presence of wiring faults as describe hereinafter.

(b) They originate at the system head-end equipment, and each consist of a Class "A" loop, the sending portion of which feed through outlying equipment control cabinets in which "branch" SLC's are tapped from the loop. The return portion of the loop is run directly - without intervening connections - back to the head-end equipment for termination.

(c) The loop conductors are run in raceways (as specified hereinafter) throughout. The "sending" portion of the loops are physically separated from the "return" by a distance of not less than 50 feet (15 meters) except where they come together at the FACP, and each is 2-hour rated as hereinafter specified.

(d) Within each outlying equipment control cabinet, and at the "sending" and "return" connections at the system head-end equipment, each loop incorporates isolators to sectionalize the loops. Two isolators per loop are provided in each outlying equipment control cabinet. They are so arranged that the wiring within the cabinet and the outgoing branch circuits can be completely isolated from upstream or downstream faults on the trunk loops.

(e) The trunk SLC's - in conjunction with their associated isolators and head end equipment - function so as to provide bi-directional signal transmission enabling receipt of alarms and signals at the fire command station (FCS), and activation of addressable control modules from the FCS, in the event of a single open, a single ground, a wire-to-wire short or an open and a ground anywhere on the circuit. The only loss of transmission is for devices and/or modules connected to that portion of the loop (between isolators within the ECC) on which the wiring fault has occurred. Wiring faults on the loops, result in trouble signals at the FCS which identifies the location of the faults.

3. "Branch" SLC's comply with the following:

(a) They are NFPA72, Style 6, arranged to limit the loss of signal transmission as described hereinafter.

(b) They originate at outlying system equipment control cabinets (ECC's), and each consist of a Class "A" loop which is tapped from - and returns to - a "trunk" SLC, together with any transponders or other electronic components required to properly interface "trunk" and "branch" SLC's. Sending and return conductors are separated by a distance of not less than 20 feet (6 meters) except where they come together at ECC's, devices or modules.

(c) Where required for the accommodation of auxiliary control relays associated with outlying addressable control modules as described in later subsections, incorporate additional supervised power supply conductors originating at the ECC's.

(d) Include multiple "branch" SLC's within outlying system equipment control cabinets (ECC's) as required to insure that no more than 50 alarm initiating devices and/or addressable monitoring modules associated with non-addressable alarm or supervisory initiating devices are connected to a single "branch" SLC. Each "branch" SLC is tapped from a "trunk" SLC by means of isolators which will disconnect it from the "trunk" SLC in the event of a wire-to-wire short (and will initiate a trouble signal identifying the fault at the FCS) so as to allow the remaining "branch" SLC's originating within the same ECC to function normally.

(e) The loop conductors are run in raceways (as specified hereinafter)

(f) The "branch" SLC's function in conjunction with upstream circuitry and head-end equipment so as to provide bi-directional signal transmission enabling receipt of alarms and monitoring signals at the FCS, and activation of addressable control modules from the FCS, in the event of a single open, a single ground or an open and a ground on the circuit. Wiring faults on the circuits result in trouble signals at the FCS, identifying the faulted circuit.

4. Initiating device circuits (IDC's) comply with the following:

(a) They are NFPA72, Style B, so arranged in conjunction with field installed end-of-line devices as to be operational in the event of a single ground, and transmit trouble signals to the FCS via their associated monitoring modules (AMM's) in the event of an open or ground on the circuit. Such signals identify the AMM.

(b) Conductors for IDC's are installed in accordance with the requirements specified above for "branch" SLC's.

5. Notification appliance circuits (NAC's) comply with the following:

   (a) They are NFPA72 Style Y circuits, originating at the associated equipment control cabinets, and so arranged in conjunction with end-of-line devices as to permit audible or visual signal operation in the event of a single ground. Wiring faults cause receipt of trouble signals at the FCS identifying the faulted circuit.

   (b) Conductors for NAC's are installed in accordance with the requirements specified above for "branch" SLC's, with the additional requirement that each is 2-hour rated as hereinafter specified until they enter the evacuation signaling zone that they serve. .

6. Circuits supplying outlying intercom stations (floor wardens stations) and outlying annunciators comply with the requirements specified hereinbefore for notification appliance circuits (NAC's).

7. Alternate circuitry and equipment arrangements which provide equal reliability (i.e., the ability to transmit and receive signals in the event of wiring faults) will be considered acceptable subject to proof of the reliability equivalence. In particular, systems employing dual communications buses will be considered if automatic transfer between buses without the loss of existing information - occurs in the event of a wiring fault or equipment failure associated with one bus.

8. Risers or trunk circuits supplying multiple floors are so arranged as to protect against the inability to initiate evacuation signals on more than one floor (or zone) in the event of fire on a single floor. To accomplish this, sending and return portions of loops or dual communications buses are so located as to be separated by a distance of not less than 50 feet (15 meters), and each is 2-hour rated as hereinafter specified.

9. Note that the use of "T-taps" or other such wiring techniques that limit the ability of addressable devices, addressable modules, loudspeaker, strobes or other devices to function normally in the event of wiring faults as described hereinbefore will not be allowed.

10. Provide the following as 2-hour rated cable or cable system except where enclosed within 2-hour rated construction as indicated on the architectural drawings:-

    (a) Trunk signalling line circuits (Trunk SLC’s).

    (b) Notification appliance circuits (NAC's) until they enter the evacuation signaling zone that they serve.

G. System equipment is of a type which insures that all signal and communication circuits are of the "power limited fire protective limited fire protective signaling type" as defined in Article 760 of the National Electrical Code.

H. Outlying system equipment control cabinets (also referred to as equipment control cabinets or ECC's) are distributed throughout the project and incorporate all required circuit isolators, transponders, notification appliance addressable control and monitoring modules, power supplies, terminal strips and other equipment and wiring as required to provide all specified system features and functions. ECC's supplying multiple floors will be considered acceptable if they are contained, together with associated conductors in a two hour rated enclosure or space, and if they comply with the following:

1. Each floor supplied by an ECC is served by a separate "branch" SLC (or more than one if needed to comply with other criteria specified hereinafter), and such "branch" SLC(s) serve only that floor.

2. A cabinet is provided on each floor, complete with interconnecting circuitry to the ECC from which it derives, to make available (at a similar location on each floor) terminals for the connecting of circuitry extensions to all devices (addressable initiating devices, addressable modules, loudspeakers, strobes, intercom stations, sub-system interfaces, and other items) which maybe required for the floor when it is fully occupied and fitted out. Terminals and interconnecting circuitry are as required to permit all system features and functions described within this Fire Protective Alarm System specification to be incorporated for each floor.

I. ECC's are not located in electric closets. They are located in suitable 2-hour rated spaces as approved by the Engineer and/or where specifically shown on the drawings. Provide (coordinate with GC) 2-hour rated access panels where required. ECC's incorporate NEMA 1 enclosures, hinged lockable doors, electric supervision against unauthorized access and the removal of any components, and each have an attached engraved nameplate identifying the cabinet. If (as described hereinafter) distributed amplification for the fire evacuation public address system is optionally provided in lieu of the specified central amplification system, all required equipment is incorporated as part of the outlying ECC's - either in the same cabinets - or in separate supervised cabinets mounted adjacent thereto.

J. Outlying addressable module boxes (or cabinets) are distributed throughout the project and contain addressable monitoring and/or control modules as follows:

1. An addressable monitoring module ("initiating device" type, i.e., AMM/ID) is provided adjacent to each sprinkler or standpipe waterflow device and each non-addressable alarm or supervisory initiating device.

2. An addressable control module (ACM) is provided adjacent to each fan motor controller (or other device controller) for equipment whose operation must be automatically and/or manually controlled by the fire alarm system. Where two items are to be controlled at the same location, two such ACM units are provided.

3. An addressable monitoring module ("status" type, i.e., AMM/S) is provided adjacent to each fan motor controller (or other device controller) for equipment whose operational status must be monitored by the Fire Alarm System. Where two status indications are to be monitored for equipment items (such as smoke purge dampers), two such AMM/S units are provided.

4. Auxiliary relays are provided to comply with requirements specified hereinafter.

K. System supervision of outlying circuitry and equipment incorporate the following:

1. Supervision against circuitry wiring faults as described hereinbefore.

2. Supervision against unauthorized access and/or removal of components at ECC's as described hereinbefore.

3. Supervision of addressable alarm initiating devices, addressable control or monitoring modules, and other outlying devices against removal, or - as described hereinbefore - against malfunction.

4. Supervision of power supplies. Failure of any system power supply causes a trouble signal at the FCS identifying the affected power supply.

5. Supervision of smoke detector/sensor device sensitivity so as to provide a "dirty head" notification at the FCS identifying the affected device.

6. Supervision against loss of voltage at any system component requiring power for its proper operation. Such failure causes a trouble signal at the FCS identifying the location of the affected device(s).

7. Supervision against "off-normal" manually initiated actions at the FCS. Any such action causes an identifying trouble signal at the FCS.

L. Power supplies serving visual warning signals are of the regulated type having an output of 28 VDC (adjustable to 30 VDC) ±3 percent.

M. The system incorporates alarm (and other) operating features as follows:

N. Reset of all alarm initiating device circuits, alarm notification circuits, and equipment control relays is accomplished from the fire command station. Manual fire alarm stations require local reset before central reset from the fire command station is possible. <u>In no case will the above alarm reset</u> <u>procedure cause the re-setting of equipment control</u> <u>relays</u>. Such devices require <u>separate</u> reset from the fire command station.

O. It is possible to disconnect any floor, or any device or combination of devices on any floor, from the system to allow for maintenance, repairs, or the addition of system devices and wiring without disabling any other floor. Such disconnection causes a visual "disabled" annunciation at the fire command station identifying the floor and/or devices.

P. Each manual station, smoke or heat detector, sprinkler/standpipe alarm or supervisory actuating device, and sub-system alarm or supervisory initiating device

constitutes a separate zone for reporting to the fire command station. For display at the fire command station (FCS) and at outlying annunciator(s), each reporting zone (i.e., device) is individually identified, except that multiple smoke detectors (or multiple heat detectors) located within a single space may be identified by a common display. It is possible to separately identify and display the address of the individual detector(s) in alarm within any such space by means of an appropriate command at the FCS keyboard or keypad.

Q. The system provides for intercom and fire evacuation public address features as follows:-

1. The system is of a dual channel type, capable of automatically broadcasting alert tones followed by recorded announcements repetitively to all floors followed by evacuation tones. No tone signals is broadcast in stairwells.

2. Manual "on-off" control from the fire command station of evacuation tone signals, recorded announcements and flashing of strobes through loudspeaker stations on any or all floors. Manual deactivation of the loudspeaker evacuation tones from the fire command station does not deactivate flashing strobes.

3. Initiation of voice announcements from the fire command station through loudspeaker stations on any or all floors, and separately through loudspeaker stations in stairwells.

4. Intercom between fire command station and any floor warden station, such intercom being controlled from the fire command station. Call initiation from warden stations to fire command station is possible.

5. Intercom use does not interfere with simultaneous broadcasting of evacuation signals, alert tones or voice announcements over system loudspeakers.

6. Patching in of voice announcements from any floor warden station to the loudspeaker stations on any or all floors, such patching in being controlled from the fire command station.

R. The fire evacuation public address equipment in the system includes the following features and functions:

1. Amplifiers are sized to accommodate a quantity of speakers equal to that shown on the drawings, plus an additional bulk quantity of 10 speakers intended for installation at locations as directed throughout the system. Sizing is based on an average requirement of 2.0 watts per speaker.

2. Amplifiers have a frequency response range of ±1.5 dB from 30 to 10,000 hertz and at rated output, less than 2 percent distortion over the frequency range of 60 to 15,000 hertz.

3. Failure of a power amplifier shuts down the amplifier and indicate a trouble condition. Amplifiers are arranged in such manner, either by pairing or automatic switchover, to provide redundancy.

4. Tone oscillators, microphone circuits and ancillary equipment are paired in

a similar fashion to the amplifiers and be provided with either automatic or manual switchover to the redundant system.

5. Where the audio path consists of twisted pair "riser cables," it includes double the number of required pairs (as determined by the total number of speakers called for). Connections at the amplifiers are arranged to readily allow their "transfer" to future amplifiers as necessary.

S. In lieu of the central amplification system described above, distributed amplification may be provided, however, such equipment conforms to the redundancy requirements described hereinbefore, and the outlying equipment must derive its power from the central equipment.

T. Provide an outlying annunciator at each location shown on the drawings. Each outlying annunciator duplicates visually and audibly all "alarm," "trouble" and "supervisory" signals received at the fire command station. Each outlying annunciator also includes a master intercom station to duplicate all functions of the master intercom station at the fire command station. The annunciators are of the cathode ray tube type or of the LCD type as utilized at the FCS. If local code authorities require other means of display, modify annunciator type so as to fully comply.

U. Each floor warden station is semi-recessed. The station is painted Fire Department red and is clearly identifiable as to its function. It contains detailed operating instructions on a plate or label which is clearly visible when the station is opened. The body of the station contains: a telephone handset, call-in pushbutton or alternate call initiation method, indicator lamp, circuit electronics, and terminal strips. The handsets are red molded thermoplastic with stainless steel armored cord, and utilize commercial type transistor components. In rooms with fire pumps or fire water tanks, stations incorporate a long extension cord and take up reel for "remote" handset operation. Furnish a warden station for each elevator, and turn over to the elevator manufacturer for flush mounting in each cab.

V. Whether indicated on the drawings, or not, a "rescue type" fire warden's station is provided in each "area of rescue assistance". Refer to the Architectural drawings for locations of such areas. "Rescue type" stations comply with the requirements for general floor warden's stations and additionally include a visual "call acknowledged" signal to indicate to hearing impaired persons that the call has been received at the fire command station. Include provisions at the fire command station to transmit an acknowledgment signal to "rescue type" fire warden's stations.

W. Loudspeakers are wall mounted (or column mounted) as noted on the drawings. They are approved for "Fire Alarm Service," with an audio power rating of at least 2 watts and a frequency response of 400 to 4,000 Hz. They have a typical sound pressure rating of at least 90 dBA at 10 feet (3 meters) when measured in an anechoic chamber. Where greater sound pressure levels are required to insure audibility, speakers of higher wattage are utilized. In particular, 15 watt speakers are utilized in mechanical rooms where the ambient sound level exceeds 70 db. Loudspeakers comply with UL Standards applicable to loudspeakers for fire alarm use. The speaker is able to withstand 150 degrees F (55 degrees C) for three hours and still operate. The speaker is equipped with a multi-tapped matching transformer and a line supervision capacitor. The work of this section includes coordination of matching transformers and field settings of taps as required to insure code compliant audibility throughout. Each loudspeaker incorporates a visual warning signal (strobe) except as described hereinafter.

X. Loudspeaker enclosures are in accordance with the following:

1. Each loudspeaker enclosure assembly except those in stairs incorporates an integral visual warning signal (strobe) as described hereinafter.

2. Where indicated as being of the flush mounted type, they each consist of a round or square grille plate and flush mounting back box.

3. Where indicated as being of the surface mounted type, they each consist of an integral assembly of grille and enclosure, fully enclosing the speaker and matching transformer.

4. Where indicated as being of the bracket type, they each consist of an assembly of bracket mounting frame and speaker enclosure. Where two loudspeakers are shown in a back to back configuration, or where the speaker is called-out as bi-directional, the two speakers are incorporated into a single assembly.

5. Loudspeaker enclosures are finished in red.

Y. A visual fire warning device is incorporated as part of each loudspeaker assembly except as noted hereinbefore.

Visual fire warning devices are as follows:

1. They are suitable for synchronized operation at a flash rate of 1 to 1.1 flashes per second, and are of the self-synchronizing type or are suitable for use with synchronizing control units integral with the power supplies, or interpolated in the circuitry between power supplies and strobes (visual warning devices). Where not of the self-synchronized type, provide a sufficient quantity of synchronizing control units to fully utilize the installed power supply capacity for the project.

2. Each visual warning device consists of a U.L. approved xenon flash tube (strobe) with matching socket, integral factory mounted diode or other device (to permit the supervision of circuitry) and domed plastic lens to flash the word FIRE when activated. The strobes have a U.L. 1971 listed intensity of at least 75 candela. Where installed in corridors or in a room having no dimension greater than 20 feet (6 meters), a strobe having a U.L. 1971 listed intensity of 15 candela and a near-axis (i.e., non-polar distribution) intensity of at least 75 candela may be utilized.

3. Strobes are suitable for operation at a nominal voltage of 24 volts D.C. from power supplied by the system.

4. Strobes continue to flash until the system is reset.

5. If approved speaker/strobe units are not available in timely fashion, separately mounted strobe units may be provided, installed at adjacent locations as approved by the Architect. Under no circumstances are ceiling mounted strobe units be installed unless specific approval has been received in writing from the authorities having jurisdiction. Relocate any strobes indicated as ceiling mounted to locations approved by the Architect.

Z. Where separately mounted visual fire devices are indicated on the drawings, each device is of the type described above for the combined loudspeaker/strobe unit except that it is equipped with backbox and mounting plate intended for flush or surface wall mounting as directed. Unit is finished as directed.

AA. Two or more loudspeaker circuits are provided to supply loudspeaker stations in each evacuation signaling zone. Loudspeakers in stairs are circuited separately from those on floors. Strobes are circuited as required, with no less than two circuits per evacuation signaling zone. Both speakers and strobes are connected to these circuits so that adjacent speakers are connected to different circuits, and similarly for strobes.

BB. In addition to the loudspeakers shown on the drawings, provide a bulk quantity of **[ ]** loudspeakers (each with integral or adjacent strobe) complete with circuitry as required, and installed at locations as directed, throughout the project. Information does not exist at this time as to the proper locations at which these loudspeakers are to be installed. The system includes adequate capacity to accommodate these loudspeakers and strobes from adjacent outlying equipment cabinets, assuming an equal distribution among the system cabinets. The work of this section includes the responsibility for determining such locations based on tenant occupancy space planning drawings on a floor by floor basis as they are prepared by the Architect and/or interior designers or space planners. As noted hereinafter, this bulk quantity of loudspeakers <u>is not to be included in the base bid</u> <u>quotation</u>, but is to be included as part of a separate "breakout" quotation.

CC. In addition to the loudspeakers described above, furnish one loudspeaker for each elevator cab, and turn over to the elevator manufacturer for flush recessed mounting in the cabs.

DD. In addition to the loudspeakers described hereinbefore, provide one weatherproof loudspeaker/strobe at each exit on to each roof. The speakers are each complete with circuitry and are exterior mounted over or adjacent to the bulkhead door.

EE. Each manual station is of the non-coded, electrically supervised type. The station is semi-flush, finished fire alarm red. The station is clearly labeled as to function and operation. The stations each include an integral addressable monitor module (AMM) to permit a separately identifiable signal to be transmitted to the fire command station via signaling line circuits as described hereinbefore. The station's "electronics" are mounted behind the body of the station, accessible by authorized personnel only. Alternately, the AMM may be separately mounted adjacent to the manual station and interconnected thereto, as described hereinafter. Manual stations located in unheated spaces have their associated AMM located in a nearby heated space as indicated or as directed by the architect.

FF. Smoke detectors (also referred to as smoke sensors or sensor/detectors) are of the analog-addressable spot detector type. They are UL approved and installed in accordance with the manufacturers recommendations as to spacing and suitability for use in the specific application with consideration for the number of air changes per hour, ceiling height, ceiling profile, normal space environment (i.e., office space as compared to boiler rooms, etc.) and the type of risk. Detectors, for ceiling mounting in finished spaces, are of the semi-flush type. It is understood that semi-flush mounting requires the device to be suitable for application to a concealed outlet box.

GG. Except as noted below, smoke detectors are of the ionization principle dual chamber type with UL approved field adjustable sensitivity features.

HH. Smoke or heat detection devices indicated in kitchens and boiler rooms are of the 190 degrees F (88 degrees C) "fixed temperature only" type.

II. Smoke detection devices in laboratories and maintenance shops and [garage areas are of the photoelectric cell type.

JJ. Smoke detectors indicated in mechanical equipment rooms are of the combination photocell plus fixed temperature/rate-of-rise type.

KK. Smoke detection devices have integrally mounted pilot lamps giving a "triggered" indication.

LL. Smoke detection devices which are mounted in ducts or under raised floors or in ceiling plenums are supplied with remote "triggered" indication pilot wired in parallel, in an approved manner, with the similar pilots included integrally with detection units. The pilots for duct detectors are each flush or surface mounted within 15 feet (4.5 meters) circuiting distance of its associated detector. Mounting and location are as directed by the Architect. The pilots for detectors under raised floors or in ceiling plenums are remotely mounted in a graphic annunciator panel at a location within the computer space as directed.

MM. Smoke detectors mounted in rooms with doors are each equipped with a remote "triggered" indication light wired in parallel with the pilot light integral with the detector. These remote pilot lights flush mounted in the corridor over or adjacent to the door to the room as directed by the Architect.

NN. Smoke detectors indicated as being located in floor or ceiling cavities of the air handling type are equipped with "air shields" where air velocities are such as to require these appurtenances for the proper detection of smoke.

OO. Heat detectors located in sprinklered elevator machine rooms or elevator shafts are of the 135 degrees F (57 degrees C) "fixed temperature only" type.

PP. Duct smoke detectors are installed in accordance with the manufacturer's recommendations as to suitability for use in the specific application with consideration to air changes, size of duct and location within duct, and include sampling chambers and pick up tubes where required. Where installed within ducts and/or above ceilings in air plenums, the provision of access doors and mounting holes in such ducts and plenums will be separate from this work. The installation of the tubes and sampling chambers, however, is part of the work of this section. In addition, responsibility for supplying detailed drawings showing exact dimensional locations of sampling tubes, etc., in the plenums and ducts, as required for the optimum operation will be part of this work. Where duct configuration is such as to interfere with laminar air flow, special provisions are included as follows:

1. For <u>unducted</u> return systems, provide area type detectors, suitable for 500 feet per minute (150 meters per minute) air velocity, pipe mounted in the ceiling at the entry to the fan room. While every attempt has been made to properly define the required quantity of detectors (labeled “d”), at each such location, it is understood that detectors are provided on the following basis, regardless of the indicated quantities:

Duct width	Quantity of detectors
not more than 36 inches (91 cm)	1
greater than 36 inches (91 cm) but not more than 72 inches (182 cm)	2
greater than 72 inches (182 cm)	2 + (1) per each additional 24 inches (61 cm)

QQ. Where combination photo-electric or ionization, plus heat, detectors are called for, separate units may be optionally substituted and their locations adjusted accordingly.

RR. Control and monitoring of audible and visual alarm notification devices (loudspeakers and strobes) and associated circuitry is by means of addressable modules located in outlying system control cabinets.

SS. Reporting of all required alarms and supervisory signals to the Fire Command Station (FCS) from initiating devices of the non-addressable type, including (but not limited to) sprinkler and standpipe waterflow and supervisory devices, manual fire alarm stations, sub-system (e.g., clean agent, pre-action sprinkler, etc.) alarm and supervisory contacts, and the like is accomplished in conjunction with addressable monitoring modules of the initiating device type (i.e., AMM/ID). AMM/ID's are of a type intended for connection of NFPA 72, Style 6 "branch" signaling line circuits (SLC) as described hereinbefore and are connected to the appropriate SLC on the floor on which they are located. Except where incorporated as part of manual fire alarm stations (or in the outlet boxes on which they are mounted), AMM/ID's are mounted adjacent to the associated initiating devices in outlying addressable monitor module boxes and are complete with engraved red nameplate. Each AMM/ID is interconnected to its associated initiating device by means of an initiating device circuit (IDC) as described hereinbefore. Provide an end-of-line resistor at each initiating device so as to permit supervision of the interconnecting circuitry. Terminals are incorporated in each addressable module box for the accommodation of all entering conductors.

TT. Control (automatic and/or manual) and status reporting (monitoring) of equipment via the fire protective alarm system as specified hereinafter is accomplished by means of addressable control modules (ACM's) and addressable monitoring modules of the status reporting type (AMM/S's) located within 3 feet (1 meter) of the controlled equipment in outlying addressable monitor boxes similar to those specified above for the AMM/ID's. Addressable modules (ACM's and AMM/S's) are provided in accordance with the following:

1. ACM's and AMM/S's are of a type intended for connection to NFPA 72, Style 6 "branch signaling circuits (SLC's) as described hereinbefore, and are connected to the appropriate SLC serving the floor on which they are located.

2. Each ACM provides (2) SPDT contacts suitable for use at voltages up to 250 VAC and capable of interrupting 10 amperes inductive, and derives its operating and supervisory current at 24VDC from the SLC. If necessary, these contact ratings are accommodated by means of auxiliary control relays mounted within or adjacent to the same addressable monitor boxes as the ACM's, and deriving their operating power from the associated ACM's, or directly from the associated ECC via separate supervised power supply conductors.

3. Each AMM/S functions so as to provide a readily identifiable status indication at the FCS in response to a 120 or 208 VAC signal from the associated controlled equipment. Incorporate an auxiliary status (monitoring) relay for each AMM/S to convert a 120 or 208 VAC AC signal to a "dry" contact if the AMM/S requires a "dry" contact for proper status

signal initiation. Auxiliary status relays, if required, are mounted in the same outlying addressable module boxes as their associated AMM/S's.

4. At locations where multiple equipment controllers are installed, the addressable modules (and any associated auxiliary relays) may be grouped in common addressable module boxes.

UU. System operation is such as to provide automatic and/or manual control of fans larger than 2,000 CFM (56 cubic meters per minute), and of dampers and other equipment in response to alarm initiation, as well as central status reporting. Additionally, any fans over 2,000 CFM (56 cubic meters per minute) which are found not to require automatic control by the FPA system are provided with manual control (and status reporting) from FCS. Controls are provided in accordance with a schedule on the drawings and/or as described hereinafter. Include provisions at the FCS in outlying system equipment control cabinets, and in outlying addressable module boxes (or cabinets) - each located within 3 feet (1 meter) of the associated motor controller, smoke purge damper control device or other equipment control device, control circuitry extensions (i.e., final connections) from the addressable module boxes to the controlled equipment and connections, all as required to achieve this control.

VV. Outlying addressable module boxes, each complete as indicated, are provided for equipment requiring automatic or manual control by the FPA system on the basis of the following:-

1. One box including two ACM's ("stop", start") and one AMM/S ("running") for each fan over 2,000 CFM (56 cubic meters per minute) (including fans in self-contained air conditioning units).

2. One box including two ACM's ("purge", "override purge") and two AMM/S's ("open"/"closed") for each smoke purge damper system. Refer to HVAC floor plans and risers for quantity of smoke purge damper systems (i.e., one system for each penetration of any multi-floor duct which will be used for smoke purge, and for each fan system which includes direct outside exhaust provisions).

3. One addressable module box for each damper requiring individual manual control from the central damper control panel (specified hereinafter for normal after-hours control), but for which direct manual or automatic control by the fire alarm system is not specified. Include one ACM ("closed") and one AMM/S ("closed").

4. One addressable module box, including three ACM's ("recall", "recall to alternate floor", and "elevator not safe for use ") and one AMM/S ("elevators recalled") for each bank of elevators. Alternate floor recall: is initiated only in response to detector activation on the terminal floor. Elevator not safe for use: is initiated only in response to detector activation in associated elevator machine room or elevator shaft. Provide two additional ACM's ("de-energize/re-energize elevator power panel) for each bank of elevators if the elevator machine room and/or associated shaft is sprinklered. Also, include one AMM/S per bank ("panel de-energized").

5. One addressable box, including one ACM for the fire stair door unlocking

system.

6. One addressable module box, including one ACM, for the fire/smoke door release system.

7. One addressable module box, including one ACM for each fire stair or elevator machine room smoke vent.

8. One addressable module box, including one ACM for each escalator controller.

9. Additional addressable module boxes as necessary to comply with the scheduled control of equipment in response to system alarm actuating devices.

WW. System operation includes manual over-ride control from -- and status reporting at -- the fire command station for each item of "controlled equipment" (such as fans, dampers, fire doors, elevators, etc.) which is to be automatically controlled in response to the operation of system alarm actuation devices as scheduled elsewhere, and for each smoke exhaust (purge) damper system and smoke purge fan. Re-start of fans shut down by an alarm is possible without clearing the alarm condition, (so as to assist in the smoke control) but only if a Fire Department key has been inserted in the Fire Command Station. Manual control of elevators will not be required, however, status reporting will be required on a per bank basis. Additional "manual only" control of certain fans and dampers (plus status) reporting) is provided if specified herein or scheduled on the drawings. To accomplish the aforementioned status reporting and manual control, include all required switching and status reporting devices at the Fire Command Station, and other necessary equipment at outlying equipment control cabinets and addressable module boxes, and all associated wiring, interwiring and final connections.

XX. Provide interface circuitry for each damper requiring individual after hours control from the central damper control panel as described hereinafter, run from the fire command station to the central damper control panel. Provide relay contacts and other necessary components, and connect as required to establish "over-ride" open/close control of the dampers from the fire command station regardless of any actions occurring at the central damper control panel.

YY. The project contains multiple smoke exhaust (purge) systems, each requiring automatic purge initiation. Manual "purge" and "override purge" control will be required and is such as to require resetting at the fire command station for each attempt to "purge" or "override". Any re-attempts to "purge" or "override" subsequent to failure of dampers to operate requires manual resetting, as does the restoration of the fire alarm system to "normal" after an "alarm" condition. To accomplish smoke purge, include:

1. Manual switching and status reporting devices, automatic control devices and other necessary equipment and wiring, at the fire command station (FCS) to automatically or manually re-open, on a floor-by-floor (or zone-by-zone) basis, dampers which have been automatically closed in response to smoke (and which must be opened to permit purge) and to open normally closed smoke exhaust dampers. Where multiple damper systems require control for purge of a single floor or zone, they are controlled as a group.

2. Include damper "open"/"closed" group status indications for the purge dampers and separately for the isolation dampers on a floor by floor basis.

3. Equipment and wiring at the fire command station to automatically or manually start the smoke exhaust system motors and to indicate system status as well. Where multiple fans are required for purge of a single floor or zone they are controlled as group. Where the smoke exhaust shafts are normally used for other purposes (minimum outside air, return, etc.), the starting of the smoke exhaust fan system motors is preceded by the automatic shutdown of all other fans served by the shaft. Include equipment and wiring at the fire command station to accomplish this.

4. Addressable modules at outlying system equipment central cabinets and addressable module boxes and interconnecting circuitry and control circuit extensions, as required to accomplish the aforementioned operation of motors and dampers in conjunction with smoke purge, as described hereinbefore.

ZZ. Control of smoke exhaust system dampers has been specified hereinbefore on a system by system basis. For the purpose of quantifying the systems, it is understood that a separate system is required for:-

1. Each fan system including recirculating air systems, which includes provisions for exhaust directly to the outside.

2. For each fan used for smoke exhaust, include three (3) additional damper systems.

Refer to HVAC air flow riser diagrams, control diagrams and/or floor plans for

information as to the required smoke exhaust dampers. Refer to "Smoke Exhaust System Wiring Diagram" for detailed information regarding wiring arrangement. "No cost" modifications to this wiring arrangement will be considered for approval.

AAA. Include in the central equipment the means of controlling damper operation so as to allow smoke purge operation at any floor or combination there of for all control fan systems.

BBB. Manual control of supply and return floor isolation dampers on each floor will be required for normal building after-hours operation from a central damper control panel (CDCP), utilizing fire protective alarm system central equipment, outlying equipment control cabinets and circuitry as described hereinbefore. Additionally, these dampers will require manual override from the fire command station (FCS) and automatic control of dampers for smoke control as described below and/or specified hereinbefore. Note that the automatic control sequences and the manual control from the FCS overrides the CDCP control. To accomplish this control, include as part of the fire alarm system:

CCC. The central damper control panel (CDCP) consists of a code gauge sheet steel housing incorporating an open/close control switch and status pilot light for all dampers on each floor requiring individual floor manual control. It also includes all encoder transponders, power modules, equipment control and status reporting relays and ancillary devices as required for the proper operation of the dampers via the aforementioned tie to the fire command station as follows:

1. Open/close control and status reporting for each floor group of dampers. Control is so arranged that it will be overridden by fire alarm system automatic operation or by manual operation from the fire command station.

2. The central damper control panel is located adjacent to the Central Mechanical Panel as directed.

3. Addressable modules (and other necessary items) at the outlying cabinets and addressable boxes, control circuit extensions and interconnecting circuitry as specified hereinbefore, and/or as otherwise needed to provide the specified control functions.

DDD. For each central multifloor system supply fan whose return ductwork will be used for smoke purge provide (at the fire command station), equipment and wiring as required to automatically close all supply and return dampers on the floors served by the system, in response to alarm initiation, and to make available a control source (via a system "master" E.P. or process control device) for selectable floor by floor damper operation for smoke control. Provide a control module in the appropriate equipment control cabinet and control circuit extension to the "master" device. Modules for the individual dampers have been specified before.

EEE. At the fire command station, include devices to provide status reporting of the emergency generator ("running," "off") and each automatic transfer switch "normal," "emergency") plus manual control thereof. In addition, include an (8) wire control circuit extension from the fire command station to the emergency generator and each transfer switch and connect as required for status reporting and manual

control. Include auxiliary relays if required.

FFF. At the fire command station, include devices to provide time delayed (adjustable 0-180 seconds) automatic "de-energize control" of each elevator power panel in response to EMR or elevator shaft heat detector operation, plus status indication and manual re-energize control therefrom.

GGG. Provide all system equipment and circuitry as required to provide supervisory indications at the fire command station in response to operation of fire suppression equipment contacts (furnished by others) as follows:

1. The fire pump.

   (a) "Pump running".

   (b) "Failure of Power."

2. Each water tank used for fire fighting purposes.

   (a) "Low Water Level".

   (b) “High Water Level".

3. Refer to sprinkler and/or plumbing drawings for location of fire pumps and water tanks.

HHH. The fire command station (i.e., the display and control section of the central equipment which requires operator interface) includes all components necessary for the system to function as specified, and incorporates a custom built display panel arranged to match the main lobby decor as directed by the Architect. The display panel is arranged to enable a minimum of four (4) simultaneous alarms to be displayed and include an overflow indicator and alarm advance feature. The display panel incorporates a back illuminated flashing fire sign module with 3 inch (76 mm) high red letters. Components of the central equipment which do not require operator interface are mounted in racks or cabinets. If space conditions so require such equipment is remotely located within 50 feet (15 meters) of the fire command station in a nearby, unfinished, ventilated space (as directed by the Architect). All required interconnections are included and are run in conduit.

III. Overall system supervision is accomplished by means of the response to continuous interrogating signals transmitted from the central equipment. The signal transmission rate is such that an "alarm" or "trouble" signal is processed and displayed within the 10 second maximum response time specified hereinbefore, and that subsequent initiation of automatic actions (fan shutdown, e.g.) is similarly initiated within 10 seconds.

JJJ. Cathode ray tubes (or LCD displays) and keyboards are "user friendly" incorporating the following features:

1. English language display.

2. Visually displayed <u>prompts</u> for access to "help screens," "system status files," etc.

3. Keyboard includes special function keys whose functions are clearly evident, e.g., "purge," "pressure," "start," "stop," "open," "close," "status," "fans," "damper," "help."

KKK. System software is such that the use of the aforementioned special function keys enable commands to be carried out with minimum effort. For example, purging of the 4th floor is accomplished by typing "4" followed by depressing the "purge" key. This either initiates all required control functions or displays any further action required for the purge.

LLL. In lieu of the special function keys and associated software as described above, system software may be of a type which permits direct "English language" keyboard entries (without the need for look-up tables) as required for the manual control of fans and dampers for smoke purge and other smoke control functions.

MMM. System display is prioritized so as to display alarms, controlled equipment status, supervisory indications and system test reports in a sequence and format as approved by the architect and by all authorities having jurisdiction. Specifically:

1. Equipment status display is derived from addressable monitoring modules controlled by limit switches or auxiliary contacts as indicated elsewhere.

2. Equipment status and/or changes in equipment status is not automatically displayed except that changes in status of equipment may be automatically displayed if they result from a fire alarm initiation event.

3. Where the status of equipment controlled by alarm initiation is not automatically displayed, the manual steps necessary to provide this display appear on the CRT along with the alarms.

NNN. Display formats which employ mnemonic codes and/or which depend upon written text material in order to properly operate the system are not considered as meeting these specifications.

OOO. The provisions for manual control and status reporting required at the Fire Command Station to comply with the specification requirements expressed hereinbefore, in addition to the CRT and keyboard control and status features, consist of maintained contact selector switches and pilot lights, assembled complete with engraved nameplates, into a readily accessible panel section of the Fire Command Station. Include all required equipment, devices and circuitry as necessary to interface with the central equipment of the system. Status is continuously displayed, and manual control of motors, dampers and other devices is possible without resorting to the use of the keyboard and/or keypad associated with the CRT display. Lamp test provisions is incorporated for the pilot lights. If this panel section cannot be accommodated within the confines of the enclosure allocated for the Fire Command Station, then it is separately wall (or other) mounted at an adjacent location approved by the Architect and the authorities having jurisdiction, and all required interwiring is included.

PPP. The fire command station includes a graphic annunciator panel in addition to the CRT or LDC display specified hereinbefore. The panel displays:

1. Each fire reporting zone (at least one zone per floor) an LED (or other) status indication for each of the reporting device types (i.e., manual station area smoke detector, duct smoke detector, heat detector, waterflow device,

subsystem alarm).

2. All fans and the areas served by each, with a status LED for each.

3. All smoke purge or pressurization dampers with a status LED for each.

The panel display complies in all respects with Fire/Building Department requirements regarding size, format, construction and display.

QQQ. Provide detailed dimensional shop drawings of the fire command station to the party responsible for providing the enclosure. It is understood that the installation of the fire command station equipment within such enclosure is part of this work.

RRR. Include at the Fire Command Station (FCS) a Fire Department approved key switch which must be operated in order to permit manual initiation of smoke purge and any other smoke control sequences, including the re-start of equipment shut down by a system alarm prior to the clearing of the alarm condition. This key is in addition to the basic required means of securing the entire FCS against tampering by unauthorized personnel.

SSS. As part of this work, each outlying component requiring a power supply for its proper operation receives this supply over wires extended from the central equipment in a code approved manner. Power supply circuitry is 2-hour rated cable or cable system except where enclosed within 2-hour rated construction as indicated on the architectural drawings.

TTT. The system includes the following features associated with the analog addressable smoke detectors (sensors):

1. An independent "alarm verification" feature for each individual smoke detector. In response to activation of a detector, the system does not go into alarm until the detector has been reset, and has gone into alarm once again. A suitable, adjustable, time delay is incorporated into the reset procedure. Provisions are incorporated to bypass this alarm verification feature for any or all detectors so as to comply with Fire Department requirements.

2. An independent "maintenance alert" feature for each individual detector, providing a notification at the FCS identifying any detector which is operating at or above a pre-determined adjustable percentage of its alarm threshold.

3. An independent "sensitivity adjustment" feature for each individual detector, allowing the adjustment to be made from the FCS.

4. An independent "test" feature for each individual detector, allowing detector operation to be checked from - and its sensitivity reported at - the FCS.

5. A "status report" feature which provides status reports and detector sensitivity reports for each individual detector. Status reports include a summary of any initiating devices (smoke detectors or other) which have been manually disabled by operator action. Such reports are printed out in response to a command from the FCS.

UUU. The central equipment is supplied with an emergency power unit including batteries and battery charging equipment which maintains this cabinet and all outlying equipment that it subfeeds operational without any change in status for a minimum period of twenty-four (24) hours. The emergency power unit is sized to meet the following minimum requirements: operating in normal (supervisory) mode, twenty-four (24) hours, followed by 4 hours of emergency operation, except that voice alarm signaling need operate for only (15) minutes at maximum connected load. Increase if necessary to conform to additional requirements imposed by code enforcement agency. Optionally, emergency power to supply outlying equipment may be provided by local battery and charger units contained within the equipment. Battery low voltage alarm contacts activates "trouble" indication at the central equipment. Batteries are of the sealed maintenance free type.

VVV. The central equipment and outlying equipment cabinets incorporate power supply provisions capable of accommodating strobes (either individually mounted or incorporated integrally with loudspeakers) on the basis of the indicated quantity of strobes, including any strobes specified in bulk, plus 50 percent spare. Risers are sized to accommodate an "all call" arrangement for strobe operation. Emergency power for the strobes is provided by means of batteries and chargers located in the outlying equipment cabinets, and sized for 5 minutes of continuous operation after 24 hours of supervision. Batteries are of the sealed maintenance free type.

WWW. The system includes a station for manually activating the relay (called for elsewhere) at the central equipment intended for transmission of an alarm signal and to put the building fire protective alarm system into alarm. This station is located at the telephone switchboard (or at a location as specifically directed in the field) and includes all required circuitry.

XXX. Central equipment, signal transmission facilities and outlying control cabinets has

capacity to handle spare points (which are in addition to those required for all functions hereinbefore specified and/or indicated in the drawings) in accordance with the following criteria:

1. "Trunk" and "branch" signaling line circuits (SLC's) are capable of accommodating enough spare alarm or supervisory initiating device points and spare equipment control points for future growth. Each equipment control point is understood to consist of two independent control functions plus two independent monitoring (i.e., "status") functions.

2. System equipment control cabinets accommodate trunk and branch circuits adequate for the required active points plus the spare points and devices specified above, and power supplies contained therein are adequate for these quantities.

3. The central equipment has capacity for the spare points described above, plus an additional capacity equal to 25 percent of those described above. The central equipment contains all equipment and devices necessary to activate these spare points. Any software necessary to support these points is also be included.

YYY. The system incorporates a "fail safe" control feature accounting for a lack of response to a fire alarm indication at the fire command station. The feature incorporates an "acknowledge" button on the fire command station, which if not depressed (following the appearance of a fire alarm indication) within a preset time period as stipulated by the Fire Department, will cause the evacuation tone signal to be sounded through all loudspeaker stations on the system.

ZZZ. The system is equipped with a "hard copy" printer located at the Fire Command Station or at another location as directed by the Architect. It incorporates the following features:-

1. It duplicates all alarm supervisory and trouble signals automatically generated by the system or operator action.

2. Changes in the status of fans, dampers and other equipment are not printed unless the change was automatically generated by an alarm initiation.

3. Print format is of alpha-numeric character which includes the month, day, year and time of occurrence, and the type and location of alarm, supervisory and trouble conditions which exist. Alarm, supervisory and trouble data are portrayed in English or mnemonic code which is readily identifiable (as approved by the Architect).

4. It prints out status and sensitivity reports for the analogue addressable smoke sensors automatically generated by the system or by the operator. It also prints out on command a listing of any indicating devices which have been "disabled" by the system operator.

5. It includes a carriage which accepts standard (6 inch (150 mm) minimum width) roll or fan fold paper with tractor feed.

6. It operates at a print speed of a minimum of 30 characters per second and have a print density of 10 characters per inch (4 characters per cm).

AAAA. The printer is supplied with paper feed features (bails, baskets and the like) and a suitable printer stand.

BBBB. Physical features of the Fire Protective Alarm System complies with the following:-

1. Components indicated on the drawings are located where shown. Components which are required for proper operation, but which are not indicated on the drawings are located in mechanical or electrical rooms, at accessible locations within suspended ceilings or at locations for which express permission of the Architect has been obtained.

2. The visual aspect of all components of the system which are exposed to view is acceptable to the Architect.

3. Consoles are for desk or wall mounting or for setting into an architectural wall, cabinet or table as directed by the Architect.

CCCC. Unauthorized access to operable components at the Fire Command Station is prevented by means of lockable hinged doors on panels.

DDDD. Operating instructions are provided within the FCS or mounted beyond glass in a frame adjacent thereto.

EEEE. For the Central Station Service, provide a 3/4 inch (DN 21) empty rigid conduit from the Fire Command Station to the telephone frame room. Also provide a 2 #12 THWN in 3/4 inch (DN 21) conduit run from a 20 amp fuse cutout in the Fire Signaling System cutout panel to the telephone frame room. Terminate both runs as directed.

PART 3 - EXECUTION

3.1 GENERAL

A. Submit a separate "breakout" price quotation for the bulk quantity of loudspeakers (with integral strobes) specified hereinbefore. As noted hereinbefore, this price is not to be included in the total base bid price, and is intended only to identify the bulk quantity cost should the Owner choose to exercise the option either partially or totally. This cost includes furnishing, installation and circuitry as described hereinbefore. The unit price quotation requested below is equal to the "breakout" price divided by the bulk quantity.

B. Submit separate unit price for each of the items listed below. Each unit price quotation is for complete work, furnished, installed, complete with pro-rata interconnecting circuitry as required for its proper operation. Equipment, materials and installation methods are same as for base bid. Quotations are suitable for both additions and deductions. Unit price quotations are required for:

Item No. 1	Loudspeaker (with integral strobe unit)
Item No. 2	Manual fire alarm station
Item No. 3	Smoke detector for flush or surface mounting
Item No. 4	Smoke detector (with sampling tubes) for duct mounting
Item No. 5	Wardens intercom station
Item No. 6	Individually mounted strobe unit

C. Include as part of the base bid quotation the cleaning and sensitivity adjustment of smoke detectors and sampling tubes as needed during the warrantee period and the periodic regular testing of system devices to comply with Building Department and Fire Department requirements, during the warrantee period.

D. In addition to the base bid price quotation, submit separate quotations for each of the "Service Contract" components described hereinafter. It is understood that these quotations are for a one (1) year period commencing with the expiration of the warrantee period. The "contract" is renewable, at the Owner's option, for one (1) year periods up to a total of five (5) years. The renewal contracts are based on the original, escalated by the national C.P.I. index. The quotations are for the following:

1. Inspection and Test - Provide all material and labor to test system by actuating all outlying alarm initiating devices, all manual control devices at the fire command station and annunciators, as well as verifying operation of all loudspeakers/strobes and wardens stations. Adjust as required to provide optimum system performance. Cleaning and adjusting of smoke detectors is excluded. Parts and labor for repairs and/or replacements is also excluded. Provide unit prices for all components of the system, installed in place. This service is provided at regular intervals complying with the requirements of the Building Department and the Fire Department.

2. Cleaning and Adjusting Smoke Detectors - Provide all material and labor for cleaning and adjusting the sensitivity of all area and duct type smoke detectors and sampling tubes. Cleaning is performed every six months. The sensitivity is checked once per year, and adjusted as required to insure compliance with UL requirements. Where detectors cannot be adjusted to so comply, they are replaced. Quotations are on a per unit basis for the cleaning and adjusting, with a separate quotation for replacement of any head that cannot be field adjusted to be within UL specified limits.

3. Repairs and Replacement - Provide all labor and parts as necessary to repair and/or replace any and all defective equipment components.

E. If the fire alarm system is not manufactured locally, but is supplied by a local distributor, the manufacturer will provide a "letter of support" stipulating that when - in the opinion of the engineer - the distributors efforts require backup, the manufacturer will provide at no cost to the Owner, all required technical support manpower in a timely manner during the installation period, and for a one year two year warrantee period thereafter.

F. The fire alarm system manufacturer stipulates to the following:

1. Upon acceptance of the system, the manufacturer, or his factory authorized distributor will turn over to the Owner the job-specific program information (on disk) to enable the servicing, repair and expansion of the system by any factory-approved service agency the Owner opts to utilize.

2. Prior to award of contract, the manufacturer will furnish the names of (3) factory approved service agencies located within 50 miles of the project. Such agencies are capable of providing all levels of maintenance servicing and programming as may be required. Failure to comply will be sufficient grounds for disqualifying the system manufacturer.

3.2 INSTALLATION, GENERAL

A. Install system according to NFPA standards referred to in Parts 1 and 2 of this Section.

B. Each outlying component requiring a power supply for its proper operation receives this supply over wires extended from the central equipment in a code approved manner.

C. Comply with the applicable requirements of other sections of Division 16 for locating and routing circuitry, for installing circuitry, for firestopping and for identification.

D. Adjust the sensitivity of all smoke detector (sensors) on the basis of the actual environment to which each will be subjected (i.e., air movement, ambient dust/dirt levels and temperature, humidity levels) in accordance with manufacturers instructions.

E. Paint the outside parts of all equipment cabinets and all junction boxes, pull boxes and outlet boxes red.

3.3 EQUIPMENT INSTALLATION

A. Manual Pull Stations: Mount semiflush in recessed back boxes with top of operating handles 48 inches (122 cm) above the finished floor or lower as indicated.

B. Water-Flow Detectors and Valve Supervisory Switches: Connect for each sprinkler valve station required to be supervised.

C. Smoke Detectors: Install ceiling-mounted detectors not less than 4 inches (10 cm) from a side wall to the near edge. Install detectors located on the wall at least 4 inches (10 cm), but not more than 12 inches (30 cm) below the ceiling. For exposed solid-joist construction, mount detectors on the bottom of the joists. On smooth ceilings, install detectors not over 30 feet (9 meters) apart in any direction. Install detectors no closer than 60 inches (150 cm) from air registers.

D. Loudspeaker/Strobes: Install 80 inches (203 cm) (to bottom of device) above the finished floor nor less than 6 inches (15 cm) below the ceiling. Install on flush-mounted back boxes with the device-operating mechanism concealed behind a grille or as indicated. Provide box extension and furnish collar where wall depth cannot accommodate flush backbox. Combine audible and visual alarms at the same location into a single unit.

E. Control Panels: Surface mount with tops of cabinets not more than 72 inches (182 cm) above the finished floor. Conduits are not permitted to enter the top of control cabinets. Only side and bottom entries are permitted.

F. Provide final connections (i.e., control circuit extensions) from each addressable module box to the equipment "controller" it services, utilizing THWN wires run in conduit in accordance with the following:-

1. From each box supplying a fan motor, provide a 5 #14 control circuit run in conduit to the motor controller and connect as indicated on the drawings.

2. From each box supplying a supply or return damper which must be closed by the FPA system to isolate a floor served by multi-floor fan system which will be allowed to run during a fire, provide a 5 #14 THWN run in conduit to the damper control device and end switch. Provide, for each box, a 120 volt supply from a normal panel. Connect for damper closure and status indication in response to automatic alarm initiation on the floor or manual control from the Fire Command Station. Provide a 2 #14 in conduit circuitry run to an interface control device (relay or other) for each damper. Device will be provided within 10 feet (3 meters) of the damper as part of the automatic temperature control work. Connect as directed.

3. From each box supplying a damper requiring individual manual control from the central damper control panel (CDCP), but for which direct manual or automatic control by the FPA system is not specified, provide a 5 #14 run in conduit to the damper control device and end switch. Provide, for each box, a 120 volt supply from a "normal" panel. Connect for damper closure and status indication in response to manual control from the CDCP. Provide a 2 #14 in conduit circuitry run to an interface control device (relay or other) for each damper. Device will be provided within 10 feet (3 meters) of the

damper as part of the automatic temperature control work. Connect as directed.

4. From each box supplying elevators, provide a 8 #14 run in conduit to the elevator group controller, and connect so that elevators are recalled to the terminal floor - or alternate floor - in response to operation of waterflow switch, elevator lobby detector, or elevator room smoke or heat detector, an "elevators recalled" status signal is activated at the FPA system central equipment, and an "elevators not safe for use" signal is activated in the elevators in response to operation of detectors in the elevator machine room or elevator shaft. If the elevator machine room and/or associated shafts are sprinklered, provide an additional 6#14 run in conduit from the box to an upstream device, arranged so as to provide a time delayed (adjustable 0 - 180 seconds) shutdown of the power to the elevator power panel, to permit a remote manual restoration of power from the FCS, and a "status" indication at the FCS.

5. From the box supplying the fire stair door unlocking system, provide a 2 #12 run in conduit to an adequate 120 volt supply and a 2 #12 extension in conduit to all fire stair door unlocking mechanisms. Provide any necessary low voltage supplies, and connect so that all doors are unlocked in response to the operation of any automatic alarm initiating device on the system or in response to all "elevators recalled" status signal generated by these automatic devices or by operation of the Firemen's Service key for Phase I recall. Include a 3 #12 run in conduit to a switch and pilot light station located adjacent to the FCS and manual unlocking.

6. From the box supplying the fire/smoke door release system, provide a 2 #12 run in conduit to an adequate 120 volt supply and a 2 #12 extension in conduit to all fire/smoke door release mechanisms. Provide door release mechanisms and any required low voltage power supplies, and connect so that all doors are released in response to the operation of any automatic alarm initiating device on the system. Include a 3 #12 run in conduit to a switch and pilot light station and connect for manual door release.

7. From each box supplying a fire stair or elevator machine room smoke vent, a 4 #12 run in conduit to the smoke vent release mechanism and limit switch. Include a release in response to a local smoke detector and status indication.

8. From each box supplying an escalator controller, a 4 #14 run in conduit to the controller and connect for shutdown and status indication in response to operation of any waterflow switch or smoke detector on the system.

3.4 WIRING INSTALLATION

A. Wiring Method: Install wiring in metal raceway in accordance with the following. Conceal raceway except in unfinished spaces and as indicated. Note that certain circuitry has been specified hereinbefore as 2-hour rated. These requirements are in addition to the requirements that follow.

1. Cable is run in conduit throughout, and conforms to the requirements for

nonpower-limited fire protective signaling circuit cable as expressed in Article 760 of the National Electrical Code, and is U.L. classified to conform to these requirements. For conductors #14 AWG and larger, cable insulation types THHN, THHW or XHHW is considered as fulfilling these requirements. Smaller size conductors have insulation types specifically U.L. approved as type NPLF, and so identified by markings on the outer surface of the cable at regular intervals. Conduit is electric metallic tubing or threaded metallic conduit subject to the restrictions hereinbefore specified for light and power circuitry throughout the project.

B. Minimum conductor size for circuitry supplying loudspeakers or strobes is #16 AWG copper and for all other circuitry not specifically sized elsewhere minimum conductor size is #18 AWG copper.

C. Wiring within Enclosures: Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

D. Conduits are not permitted to enter the top of control cabinets. Only side and bottom entries are permitted.

E. Cable Taps: Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

F. Color Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color code for alarm circuit wiring and a different color code for supervisory circuits. Color-code audible alarm-notification circuits differently from alarm-initiating circuits. Use different colors for visual alarm-notification circuits. Paint fire alarm system junction boxes and covers red.

3.5 GROUNDING

A. Ground cable shields and equipment according to system manufacturer's instructions to eliminate shock hazard and to minimize, to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding.

C. Connect to grounding electrode specified in Division 16 Section "Grounding and Bonding." Install grounding electrode conductors of type, size, location, and quantity as indicated. Comply with installation requirements of Division 16 Section "Grounding and Bonding."

D. Ground equipment and conductor and cable shields. For audio circuits, minimize, to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments.

3.6 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Provide services of a factory-authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.

B. Include the services of an independent certified testing agency acceptable to the local fire department, where so required by the fire department or local regulations, for pretesting and final testing. Include costs to perform testing outside of normal working hours if required by fire department or by project schedule.

C. Pretesting: After installation, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.

D. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable, including the names and titles of the witnesses to the preliminary tests.

E. Final Test Notice: Provide a 10-day minimum notice in writing when the system is ready for final acceptance testing.

F. Minimum System Tests: Test the system according to the procedures outlined in NFPA 72. Minimum required tests are as follows:

1. Verify the absence of unwanted voltages between circuit conductors and ground.

2. Test all conductors for short circuits using an insulation-testing device.

3. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit on the record drawings.

4. Verify that the control unit is in the normal condition as detailed in the manufacturer's operation and maintenance manual.

5. Test initiating and notification circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and notification devices. Observe proper signal transmission according to class of wiring used.

6. Test each initiating and notification device for alarm operation and proper response at the control unit. Test smoke detectors with actual products of combustion.

7. Test the system for all specified functions according to the approved operation and maintenance manual. Systematically initiate specified functional performance items at each station, including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications. Observe all voice audio for routing, clarity, quality, freedom from noise and distortion, and proper volume level.

8. Test Both Primary and Secondary Power: Verify by test that the secondary power system is capable of operating the system for the period and in the manner specified.

G. Retesting: Correct deficiencies indicated by tests and completely retest work affected by such deficiencies. Verify by the system test that the total system meets the Specifications and complies with applicable standards.

H. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests.

I. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.

3.7 CLEANING AND ADJUSTING

A. Cleaning: Remove paint splatters and other spots, dirt, and debris. Touch up scratches and marred finish to match original finish. Clean unit internally using methods and materials recommended by manufacturer.

B. Adjusting: Adjust sensitivity of each detector based on the environment to which it will be subjected.

3.8 DEMONSTRATION

A. Startup Services: Engage a factory-authorized service representative to provide startup service and to demonstrate and train Owner's maintenance personnel as specified below.

1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, adjusting, and preventive maintenance. Provide a minimum of 16 hours training.

2. Training Aid: Use the approved final version of the operation and maintenance manual as a training aid.

3. Schedule training with Owner with at least 7 days advance notice.

3.9 ON-SITE ASSISTANCE

A. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels, controls, and sensitivities to suit actual occupied conditions. Provide up to 3 requested adjustment visits to the site for this purpose.

END OF SECTION 16721

NEW PASSENGER TERMINAL
DULUTH INTERNATIONAL AIRPORT
DULUTH, MINNESOTA

SECTION 16741 - TELECOMMUNICATIONS DISTRIBUTION SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 SUMMARY

A. This Section includes telecommunications distribution systems, including a provision for service by the telephone utility organization.

B. Related Sections: The following Division 16 Sections contain requirements that relate to this Section:

1. "Raceways and Boxes" for telecommunications raceways, including conduit, tubing, wireways, and surface raceways.

2. "Basic Materials, Methods and Requirements (Electrical)."

3. "Electric Identification."

1.3 SUBMITTALS

A. General: Submit the following according to Conditions of the Contract and Division 1 Specification Sections.

B. Product data for system components.

1.4 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. Provide materials that are Underwriters Laboratories listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the "National Electrical Code," Article 100.

C. Coordination of Work: Coordinate the Work of this Section with the requirements of the Owner's telecommunications system suppliers and of the telephone utility organization.

1. Meet jointly with the representatives of the above organization and the Owner's representative to exchange information and agree on details of installation interfaces.

PART 2 - PRODUCTS

2.1 FACILITIES FOR ACCOMMODATION OF TELECOMMUNICATIONS WIRE AND DEVICES

A. Outlets for telecommunications wiring shall conform to the specifications for standard convenience receptacle outlets, except that they are to be without wiring devices and shall have:-

1. Raised single gang cover (where flush wall mounted) and blank plate. For wall telephone units, include provision for support of unit.

2. For each stanchion type floor outlet -- a stanchion with a bushed hole plate and capacity to handle telecommunications wiring and devices. Where supplied from circuitry run concealed in the ceiling below, each stanchion shall be of the "dual service" type, integrated with an approved fire-rated through-floor fitting capable of accommodating 120 volt and telecommunications wiring and devices.

3. For each flush type floor outlet [which does not occur integrally within the preset inserts of the specialty cast-in-floor raceway systems] -- a 3" high by 1" I.P.S. standpipe with proper adapter for a flush floor outlet.

B. Raceways: Comply with Division 16 Section "Raceways."

C. Except where specifically indicated otherwise, raceway for telecommunications wiring shall be:-

1.	For main runs	Electric Metallic Tubing
2.	For branch runs to outlets	Electric Metallic Tubing and/or Surface Metal Raceway

all raceway materials being subject to the same limitations in usage as hereinbefore specified.

D. Exclude EMT where located within 8'-0" of the floor in mechanical spaces (or otherwise exposed to mechanical damage), or intended for embedment in concrete.

E. Boxes and Cabinets: Comply with Division 16 Section "Cabinets, Boxes, and Fittings."

F. Telecommunications cabinets shall consist of code gauge galvanized sheet metal cabinets, complete with interior plywood backboards, and flush, inset covers, and prepunched knock-outs on the top, bottom and sides.

G. Backboard: 3/4-inch (19 mm) interior grade plywood. Where installed in wire closet, height and width must cover entire wall up to 8 feet (2.5 m) above floor, except as otherwise indicated.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Telephone Service: Comply with telephone utility organization requirements as to details of the telephone service.

B. Distribution System: Install completely so system will be fully operational when telephone instruments and switching equipment are connected.

C. Comply with applicable requirements for locating and routing circuitry, for installing circuitry, and for fire-stopping as described in other sub-section of Section 16050.

D. Raceway: Install telecommunications service and distribution raceway where indicated as specified in Division 16 Section "Raceways."

E. No more than two (2) 90° bends (or the equivalent thereof) in conduit for telecommunications wiring will be permitted between junction boxes, pull boxes, cabinets or other cable access points. Radius of bends in all runs other than branch runs to outlets shall be 48" minimum.

F. Wall Outlets: Install blank covers only on devices which are not to be wired at this time under another Contract. Turn over blank covers to the Owner.

3.2 RACEWAY INSTALLATION

A. Outlets for telecommunications wiring are to be circuited up with "empty conduit circuitry" in accordance with the following:-

(a) For one outlet -- 3/4"

(b) For two outlets -- 3/4"

(c) For first of three outlets -- home run only or to outlet ahead -1"

(d) or first of four outlets -- home run only -1-1/4"

B. At any location where empty conduit telecommunications outlet circuitry is extendedfrom a flush mounted telecommunications cabinet to a suspended ceiling immediately above, at least four 1-inch empty conduits shall be included (in addition to those required for present outlets) to permit future connections from the cabinet. The empty conduits shall extend up from the panel and shall terminate in a threaded conduit cap immediately after turning out into the hung ceiling space.

C. All conduits provided for telecommunications wiring terminate in approved bushings.

D. All empty conduit, circuitry or raceways for telecommunications wiring shall be provided with a minimum of nylon drag cords secured at each end.

3.3 GROUNDING

A. Install ground terminal at service location and connect in accordance with Division 16 Section "Grounding."

3.4 IDENTIFICATION

A. Identify telecommunications system backboards and cabinets with the legend "Telecommunications." Perform all identification in accordance with Division 16 Section "Electrical Identification."

B. All junction boxes for telecommunications wiring shall be clearly identified as to their function (e.g., tel, data).

3.5 CLEANING AND PROTECTION

A. Prior to final acceptance, clean system components and protect from damage and deterioration.

END OF SECTION 16741