MN/DOT Specification
Light Emitting Diode (LED) Luminaire
For Roadway Lighting at a Mounting Height of 40 feet

03/17/2014

1. LISTING REQUIREMENTS

1.1. The Luminaire shall be listed by a National Recognized Testing Laboratory (NRTL) as defined by the U.S. Department of Labor. The testing laboratory must be listed by OSHA in its scope of recognition for the applicable tests being conducted as required by this specification. A list of recognized testing labs for products sold in the United States may be found on the U.S. Department of Labor's web site: http://www.osha.gov/

1.2. The Luminaire shall be listed and labeled by a NRTL as being in compliance with UL 1598 and suitable for use in wet locations

1.3. Light source and drivers shall be RoHS compliant.

1.4. Shall have an International Electrotechnical Commission (IEC) 529 Ingress Protection (IP) rating of IP 65 or greater for the optical assemblies of the luminaire.

1.5. Shall be in compliance with Electro Magnetic Interference (EMI) requirements as defined by FCC 47 Sub Part 15; CISPR15, CISPR22 Class A (120Vmin), EN61000-3-2, -3-3, -4-4, -4-5.

1.6. Shall be tested according to the most current version of Illuminating Engineering Society of North America (IESNA) LM-79 See section 6 below.

1.7. Shall have lumen maintenance measured in accordance the most current version of Illuminating Engineering Society of North America (IESNA) LM-80 See section 8 below.

1.8. Shall have long term lumen maintenance documented according to the most current version of Illuminating Engineering Society of North America (IESNA) TM-21 See section 6 below.

1.9. Shall have LM-79, LM-80 and In-situ temperature testing conducted by U.S. Department of Energy Lighting Facts Program LED Lighting Facts approved testing laboratories.

http://www.lightingfacts.com/approvedlabs

1.10. Shall meet the light level performance requirements as listed in section 5 of this specification.

2. HOUSING:

2.1. Shall have an aluminum housing.

2.2. Shall be painted gray or bronze to increase corrosion resistance.

2.3. All hardware on the exterior of the housing including cover and latch shall be stainless steel, zinc or steel with zinc alloy electroplate and chromate top coat .

2.4. Shall be easy to open when properly mounted.

2.5. Shall be easy to open when sitting on its top side when placed on the ground.

2.6. Shall have readily accessible internal parts.

2.7. Shall have provisions for a 4-bolt slip fitter type mounting on nominal 2 inch (2 3/8 OD) pipe (tenon) brackets.

2.8. Slip fitter mount shall allow 4 inches of the pole bracket to be inserted in the luminaire mounting assembly.

2.8.1. The mounting assembly shall permit any necessary adjustment to orient the luminaire with the roadway for proper light distribution.

2.9. Shall have a clamping assembly with 4 bolts for securing the assembly to the light pole.

2.10. Shall not weigh more than 40 pounds when fully assembled.

2.11. Shall have an effective projected area of no more than 2.2 square feet (when viewed from either side or either end).

2.12. Shall be compliant with American National Standard (ANSI) IEE0 C136.31, Table 2 Roadway Lighting Equipment -Luminaire Vibration for both normal applications and bridge and overpass applications.

2.13. Shall have area on the top of the housing to allow for a level to be used for proper orientation of the Luminaire.

2.14. Shall have a 7 pin photocontrol receptacle in full compliance with ANSI C136.41-2013 "For Roadway and Area Lighting Equipment-Dimming Control an External Locking Type Photocontrol and Ballast or Driver"

2.14.1. Shall be rotatable up to 359 degrees.

2.14.1.1. Housing shall provide a stop to prevent the internal twisting of wire assemblies resulting in potential electrical shorts.

2.14.2. Shall be fully wired.

2.14.3. Shall have a rain tight twist lock shorting cap.

2.14.3.1. Shall allow the luminaire to turn on and off using a single photocell at the lighting service cabinet when a shorting cap is installed in the luminaire.

2.14.4. Shall allow a simple replacement of the shorting cap with a smart photocontrol to enable dimming and performance monitoring of the luminaire.

2.15. Shall support installation of an Electronic Control Module (ECM) for dimming and luminaire performance monitoring.

2.16. Housing shall be designed to allow water shedding.

2.17. Passive cooling method shall be employed to manage thermal output of LED light engine and power supply.

2.18. Shall have a label that states operating voltage and current range.

2.18.1. The label must be clearly visible on the inside of the housing.

3. ELECTRICAL REQUIREMENTS:

3.1. Shall fully operate in a temperature range -40° C to 40° C (-40° F to 104 ° F).

3.2. Shall consume an AC line input power of 220 watts maximum.

3.3. Shall have an integral power supply (electronic driver).

3.4. Shall have a power supply (electronic driver) that will operate within the following voltage range options:

(120 to 277 VAC (rms)) ±10% at 60 hertz.
or
(120 to 240 VAC (rms)) ±10% at 60 hertz.

3.5. Shall have a power supply (electronic driver) that has a power factor of .90 or greater at full load.

3.6. Shall have a power supply (electronic driver) that has total harmonic distortion of 20% or less at full load.

3.7. Shall have a power supply (electronic driver) that has 0 to 10 volt dimming.

3.7.1. Shall be in compliance with IEC 60929, Annex E, "Control Interface for Controllable Ballasts".

3.7.1.1. Open circuit (floating) dimming (violet & gray) conductors will force 0% dimming. The driver will provide 100% current on the outputs.

3.7.1.2. 1 VDC applied to the dimming circuit will provide 10% current out of the driver.

3.7.1.3. 10 VDC applied to the dimming circuit will provide 100% current out of the driver.

3.7.2. See Section 2 photocontrol receptacle for additional information.

3.8. Shall have power supply (electronic driver) with a rated life of 100,000 hours with a luminaire operated at an ambient temperature of 25° C (77°F).

3.9. Shall have a power supply (electronic driver) that has thermal overload protection.

3.10. Shall have a power supply (electronic driver) that is self-limited short circuit protected and over load protected.

3.11. Shall have a power supply (electronic driver) that is NRTL certified for use in dry or damp locations when installed inside an electrical enclosure.

3.12. Shall have a power supply (electronic driver) that is terminated with quick disconnect wire harnesses for easy maintenance. Wire nut termination is not acceptable.

3.13. Shall have a terminal block for terminating pole wiring to the Luminaire. The terminal block shall be a 3 station, tunnel lug terminal board that will accommodate #6 thru #18 AWG pole wire.

3.14. The luminaire shall have an integral electrical transient suppressor meeting the following requirements.

3.14.1. The electrical environment shall be defined by ANSI/IEEE standard C62.41.1™-2002 " IEEE Guide on the surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits" or the most current version.

3.14.2. In accordance with ANSI/IEEE standard C62.41.2™-2002 "IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and Less) AC Power Circuits" (or the most current version of the specification) the luminaire will be in a Category C High exposure environment.

3.14.2.1. Scenario 2 (Direct lightning flash)

3.14.2.2. Testing wave forms shall be in accordance with Table 1 standard and additional testing waveforms.

3.14.3. Surge test waveforms shall be characterized in accordance with IEEE C62.41-1 ™ -2002 or the most current version.

3.14.3.1. Location Category C
Outside, service entrance and equipment.

3.14.4. Shall be tested in accordance with IEEE C62.45™- 2002 "IEEE Recommended Practice on Surge Testing for Equipment Connected to Low-Voltage (1000 V and Less) AC Power Circuits" or the most current version.

3.14.4.1. Scenario 2 (Direct Lightning flash)

3.14.4.2. Testing wave forms shall be in accordance with Table 1 standard and additional testing waveforms.

3.14.5. Shall be a 3 wire device providing protection from Line to Ground, Line to Neutral and Neutral – Ground.

3.14.6. The transient suppressor is not required to be RoHS compliant.

3.14.7. The transient suppressor shall be a NRTL listed or recognized and labeled in accordance with the most current edition of UL 1449.

3.14.8. Fusing shall not be used to achieve required suppression levels.

4. LED PERFORMANCE REQUIREMENTS:

4.1. Shall have a minimum Luminaire efficacy of 70 lumens/watt.

4.2. Shall meet the Chromaticity requirements as follows:

The standard color for the LED Luminaire shall be White. The colors shall conform to the following color regions based on the 1931 CIE chromaticity diagram.

Nominal Correlated Color Temperature
CCT = 4000K

Manufacturer-Rated Nominal	Allowable LM-79 Chromaticity Values	
	Measured CCT (K)	Measured Duv
4000	3710 to 4260	-0.005 to 0.007

Adapted from NEMA C78.377

Color Rendering Index

Shall have a minimum Color Rendering Index (CRI) of 70.

4.3. Chromaticity as stated above must be confirmed by an Independent or certified test lab or shown on the LM 79 test report.

5. OPTICAL REQUIREMENTS:

5.1. Shall have a completely sealed optical system.

5.1.1. Shall have a (IEC) (IP) rating of 65 or greater

5.2. Shall have an Illuminating Engineering Society of North America (IESNA) Backlight, Uplight and Glare (BUG) rating as follows:

5.2.1. Backlight rating shall not exceed 3

5.2.2. Uplight rating shall not exceed 0

5.2.3. Glare rating shall not exceed 3

5.3. Shall have a light distribution pattern at the road surface that has an evenly dispersed appearance.

5.4. Shall not have a perceptible light level flicker to the unaided eye over the voltage range as specified in section 3.

5.5. An LED replacement for a 250 Watt HPS luminaire shall meet the required light levels at the following mounting and setback requirements when:

It would be mounted at a height of 40 ft.
It would be mounted on one side of the roadway.
It would light 2 lanes that are each twelve feet wide.
It would have a 23 foot set back from the right lane fog line (right edge of driving lane).
It would be mounted on a davit extending 9 feet from the pole towards the roadway.
It would be mounted on poles spaced at 250 feet.
No light from luminaires placed on the opposite side of the roadway shall be included in any light level calculations.
Using ANSI/IES RP8-00, American National Standard Practice for Roadway Lighting.

With the mounting requirements stated above the lighting unit shall provide light levels as follows:

5.5.1. Shall have average maintained horizontal illuminance in the range of 0.6 to 1.1 foot candles using a roadway classification of R2 & R3. These light levels must be documented using AGI 32 or Visual Lighting design software utilizing a Light Loss Factor (LLF) as defined below:

5.5.1.1. Calculations shall be for maintained values (Light Loss Factor (LLF) < 1.0.) where:
LLF = LLD X LDD

5.5.1.1.1. Lamp Lumen Depreciation Factor (LLD) shall be the specified percentage of LED lumen maintenance at 70,000 hours at 25C° C (77°F) from the TM-21 report.

5.5.1.1.2. Luminaire Dirt Depreciation (LDD) = .9

5.5.2. The TM-21 Report must show the drive current used for the submitted luminaire. The report can show a larger drive current to represent a worst case scenario.

5.5.3. The Lumen Maintenance Life L_{70} from the TM-21 Report must not be below 70% at 70,000 hours at 25C° C (77°F).

5.5.4. Shall have a maximum average to minimum uniformity of 4.00:1

5.5.5. Shall have a maximum allowed veiling luminance ratio $(L_{V(max)}) / (L_{(avg)})$ of 0.3:1

5.6. Shall provide independent test laboratories IES photometrics which verify light levels.

5.7. Product submittal shall be accompanied by IES TM-21 compliant test reports from a CALiPER qualified or NVLAP accredited testing laboratory for the specific model being submitted.

6. LUMINAIRE PERFORMANCE:

The manufacturer shall submit performance documentation under either option as defined below. Submitted documentation must clearly show which option the manufacturer has chosen.

6.1. Option 1: Component Performance

Under this compliance path, the manufacturer must submit calculations per TM-21 predicting lumen maintenance at the luminaire level using In Situ Temperature Measurement Testing (ISTMT) and LM-80 data. To be eligible for the Component Performance option, ALL of the conditions below must be met. If any of the conditions are not met, the component performance option may not be used and the applicant must use Option 2 for compliance.

6.1.1. The LED light source(s) have been tested according to LM-80.

6.1.2. The LED drive current specified by the luminaire manufacturer is less than or equal to the drive current specified in the LM-80 test report.

6.1.3. The LED light source(s) manufacturer prescribes/indicates a temperature measurement point (T_S) on the light source(s).

6.1.4. The T_S is accessible to allow temporary attachment of a thermocouple for measurement of in situ temperature. Access via a temporary hole in the housing, tightly resealed during testing with putty or other flexible sealant is allowable.

6.1.5. For the hottest LED light source in the luminaire, the temperature measured at the T_S during ISTMT is less than or equal to the temperature specified in the LM-80 test report for the corresponding drive current or higher, within the manufacturer's specified operating current range.

6.1.5.1. The ISTMT laboratory must be approved by OSHA as a Nationally Recognized Testing Lab (NRTL), must be qualified, verified, and recognized through DOE's CALiPER program, or must be recognized through UL's Data Acceptance Program.

6.1.5.2. The ISTMT must be conducted with the luminaire installed in the appropriate application as defined by ANSI/UL 1598 (hardwired luminaires), with bird-fouling appropriately simulated (and documented by photograph) as determined by the manufacturer.

6.2. **Option 2: Luminaire Performance**

6.2.1. Under this compliance path, the applicant must submit TM-21 calculations based on LM-79 photometric test data for no less than three samples of the entire luminaire.

6.2.1.1. Duration of operation and interval between photometric tests shall conform to the TM-21 criteria for LED light sources. For example, testing solely at 0 and 6000 hours of operation would not be adequate for the purposes of extrapolation.

6.2.2. Between LM-79 tests, the luminaire test samples must be operated long-term in the appropriate application as defined by ANSI/UL 1598 (hardwired luminaires).

6.2.2.1. The test laboratory must hold NVLAP accreditation for the LM-79 test procedure or must be qualified, verified, and recognized through the U.S. Department of Energy (DOE)'s CALiPER program.
http://www1.eere.energy.gov/buildings/ssl/test_labs.html

6.2.2.2. The extent of allowable extrapolation (either 5.5 or 6 times the test duration) depends on the total number of LED light sources (no less than 10 and preferably more than 19) installed in the luminaire samples, as per TM-21.

6.3. Under either compliance path option 1 or 2 above, values used for extrapolation shall be summarized per TM-21 Tables 1 and 2 at 25C° C (77°F). Submitted values for lumen maintenance lifetime and the associated percentage lumen maintenance shall be "reported" rather than "projected" as defined by TM-21. Supporting diagrams are required to facilitate interpretation.

7. WARRANTY:

7.1. The entire Luminaire assembly including material, workmanship, photometrics, labor, power supply and LED modules shall have a minimum of ten (10) year warranty from the date of installation.

7.1.1. If more than 10 % of the individual LED's fail within the warranty period the luminaire must be repaired or replaced.

7.1.2. The department will remove the unit from the field and ship it to the manufacturer for repair or replacement.

7.2. Shall have a 10 year warranty on the paint finish.

8. MINIMUM REQUIRED SUBMITTALS:

8.1. Luminaire specification sheet.

8.2. LED driver specification sheet.

8.3. LM-79 Luminaire photometric report.

8.4. The vendor must submit LM-79 in-situ test data to confirm thermal operating temperatures of the luminaire.

8.4.1. Supplied in-situ test data must include thermal measurements from the worst case (hottest) thermal test point on the electronic driver (power supply).

8.5. LM-80 Lumen maintenance report.

8.6. TM-21 calculations as defined in section 6.

8.7. Backlight, Uplight, Glare (BUG) rating of the luminaire.

8.8. Computer generated point by point photometric analysis using AGI 32 or Visual lighting design software.

8.9. A complete certified test lab report that shows the electrical transient suppression meets the requirements as set forth in this specification.

8.10. Written product warranty.

8.11. Independent test lab IES photometric reports.

8.11.1. Including IES electronic file.

8.12. IES chromaticity data from an LED Lighting Facts approved testing laboratory.

8.13. Instructions for installation and maintenance.

8.14. As part of the submittal process when a manufacturer submits a luminaire for inclusion on the MnDOT APL a Microsoft Word version of the MnDOT LED luminaire specification will be provided to the manufacturer. On each line of the provided MnDOT LED luminaire specification the manufacturer must identify in writing where and on which manufacturer submitted documents the item in the MnDOT specification is shown to be in compliance.

9. MN/DOT ACCEPTANCE TESTING:

9.1. Luminaire will be reviewed against each item listed on this specification. If the fixture is not in compliance with each item on this specification it will not be placed on the Lighting Approved Products List (APL).

9.2. Shall be installed by MN/DOT on a 40 foot pole to verify light levels and light pattern.

9.3. The Minnesota Department of Transportation will verify light levels using the independent test laboratories photometrics.

9.4. The Minnesota Department of Transportation reserves the right to perform random sample testing on all shipments at its own expense. Random sample testing will be completed within 60 days, and as soon as possible, after delivery. Mn/DOT shall determine the sampling parameters to be used for the random testing. If the units tested fail random testing the units will be removed from the MN/DOT Approved Products list for Lighting.

9.5. Once the Luminaire has been placed on the MN/DOT APL for Lighting no substitution of materials will be allowed unless the manufacturer has received written permission in advance from MN/DOT allowing the substitution.

9.6. MN/DOT must be notified of any change to the catalog number. This notification must include the reason for the change in catalog number.
Failure to meet this requirement may cause the luminaire to be eliminated from the MN/DOT Approved Products List (APL).