

LUMINAIRE, LED

****From Waterbury Area WKZN(9) C/2**

- xx. DESCRIPTION. This work shall consist of furnishing and installing light-emitting diode (LED) luminaire fixtures at the locations indicated in the Plans and as directed by the Engineer.

The work under these provisions shall be performed in accordance with these provisions, the Plans, and Section 679 of the Standard Specifications.

- xx. REFERENCE STANDARDS.

(a) American National Standards Institute (ANSI).

- (1) C62.41 - Characterization of Surges in Low-Voltage (1000V and Less) AC Power Circuits
- (2) C78.377 - Specifications for the Chromaticity of Solid State Lighting Products
- (3) C82.SSL-1 - Operational Characteristics and Electrical Safety of SSL Power Supplies and Drivers
- (4) C83.77 - Harmonic Emission Limits - Related Power Quality Requirements for Lighting
- (5) C136.2 - Roadway and Area Lighting Equipment - Luminaire Voltage Classifications
- (6) C136-10 - Standard for Roadway Lighting Equipment, Locking-Type Photo Control Devices
- (7) C136-14 - Standard for Roadway Lighting, Enclosed Side-Mounted Luminaires for Horizontal Burning High Intensity Discharge Lamps
- (8) C136-22 - Standard for Roadway Lighting, Internal Labeling of Luminaires
- (9) C136-31 - Standard for Roadway Lighting Equipment Luminaire Vibration

(b) American Society for Testing and Materials (ASTM).

- (1) B117-03 - Standard Practice for Operating Salt Spray (Fog) Apparatus
- (2) D522-93a - Standard Test Methods for Mandrel Bend Test of Attached Organic Coatings
- (3) D714-87(94) - Standard Test Method for Evaluating Degree of Blistering of Paints

- (4) D1654-92 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments
 - (5) D3359-97 - Standard Test Methods for Measuring Adhesion by Tape Test
 - (6) G7-05 - Standard Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials: Testing for UV Resistance
- (c) International Electro-technical Commission (IEC).
- (1) IEC 60598 - Degrees of Protection Provided by Enclosures (IP Code)
- (d) Illuminating Engineering Society of North America (IESNA).
- (1) HB-93-2000 - IESNA Lighting Handbook - 9th Edition
 - (2) RP-8-00 - American National Standard Practice for Roadway Lighting
 - (3) RP-16-96 - Nomenclature and Definition
 - (4) LM-31-95 - Photometric Testing of Roadway Luminaires Using Incandescent Filament and High Intensity Discharge Lamps
 - (5) LM-50-99 - Photometric Measurements for Roadway Lighting Installations
 - (6) LM-63-95 - Standard file format for Electronic Transfer of Photometric Data
- (e) National Fire Protection Association (NFPA).
- (1) 70 - National Electrical Code
 - (2) 502 - Standards for Road Tunnels, Bridges, and Other Limited Access Highways, 2004
- (f) National Electrical Manufacturers Association (NEMA).
- (1) 250 - Enclosures for Electrical Equipment
- (g) Underwriter's Laboratories Inc. (UL) Publications.
- (1) 467 - Grounding and Bonding Equipment
 - (2) 1029 - High Intensity Discharge Lamp Ballasts
 - (3) 1598 - Standard for Luminaires
 - (4) 8750 - Light-Emitting Diode (LED) Equipment for Use in Lighting Products

- (5) IEUR - Guide Information for Luminaire Poles

xx. SUBMITTALS.

- (a) Product Data. For each luminaire, arranged in the order of lighting unit designation. Include data on features, accessories, finishes, and the following:
- (1) Physical description of fixture, including dimensions and verification of indicated parameters.
 - (2) Luminaire weight, effective projected area, details of attaching luminaires, accessories, and installation and construction details.
 - (3) Manufacturer's recommended replacement parts list.
 - (4) LED Driver/Power Supply. Description, operating characteristics, electrical data, component/capacitor temperature rating, and reliability testing report from an independent laboratory including mean-time-between-failure (MTBF).
 - (5) LEDs and Printed Circuit Board Construction.
 - (6) LED type, ratings, and description including heat dissipation design indicating margin between the maximum rated LED junction temperature and the junction temperature at operating current.
 - (7) Light Loss Factors (lumen depreciation as a function of operating current, temperature and operating hours): Provide measurement bases for these factors.
 - (8) Photometric report illustrating iso-illuminance for the project mounting height, classification type, and cutoff characteristic. All photometric files presented shall be prepared and certified by an independent testing laboratory.
 - (9) Independent laboratory IESNA LM-79 and LM-80 Reports.
 - (10) Copy of the 3G vibration test report completed using the procedure defined by ANSI C136.31-2001 American National Standard for Roadway Lighting Equipment - Luminaire Vibration. One exception to the procedure is that only one luminaire may be used during the complete test. All costs associated with the shipping and testing shall be at the Contractor's expense. Determination of acceptability will be by the reviewing Engineer.
 - (11) All components shall be submitted with a list of all standards to which the product conforms.
 - (12) Fabrication Drawings. Catalog cuts and manufacturer's drawings. Mounting bolt templates

keyed to specific arms and certified by manufacturer.

- (13) Wiring Diagrams. Power, and control wiring.
- (14) Coordination drawings including mounting and connection details, drawn to scale, for exterior luminaries, weight of the fixture inclusive of the LED Driver, and mounting and installation details drawn to scale illustrating the requirements for the ballast installation in the transformer base.
- (15) Operation and Maintenance Data. For luminaires to include in maintenance manuals.
- (16) Provide a lighting calculation inclusive of Luminance, Illuminance, and Veiling Luminance on a grid as defined in ANSI/IESNA-RP-8-00.
- (17) Calculation(s) to be completed using the design drawings as the basis for the pole placement and mounting height. Calculations are to include average, maximum, minimum, maximum/minimum, and average/minimum for both initial and maintained luminance on an R3 roadway surface. Included with these calculations provide the veiling luminance ratio for each calculation. All maintained calculations are to include a light loss factor (LLF) of 0.71. Included as part of the lighting calculations, the fixture manufacturer shall provide their recommended Luminaire Dirt Depreciation Factor (LDD).
- (18) Warranties. Special warranties specified in this Section.
- (19) Samples. Provide (1) operable fixture, supplied with a 120V driver and a cord for tabletop review and operation. This sample will remain the property of the Agency to be used by the Engineer for quality assurance purposes during and after the project installation.

xx. 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) Luminaires, inclusive of the LEDs and LED Driver compartments, shall be UL-1598 Wet Location listed and IP66 certified.
- (c) The Engineer reserves the right to request that one fixture from the project production lot be sent to a qualified testing facility for testing to confirm the 3G vibration testing data provided as part of the submittal process. As

stated, only one luminaire may be used to illustrate conformance with the 3G testing procedure defined by ANSI C136.31-2001 American National Standard for Roadway Lighting Equipment - Luminaire Vibration. All costs associated with the shipping and testing shall be at the Contractor's expense. Determination of acceptability will be by the reviewing Engineer.

(d) Luminaires including power supply shall be RoHS compliant and lead/mercury-free.

xx. DELIVERY, STORAGE, AND HANDLING. Inspect equipment as received. Return for replacement any equipment damaged in shipment. Equipment shall be stored in a clean, dry, protected area. Retain packing as received from the factory until it is to be installed. Check and seal luminaire openings against rodents and water as necessary.

xx. COORDINATION. The Contractor shall coordinate between the luminaire manufacturer and the pole manufacturer to ensure that the proposed materials, when assembled, will conform to AASHTO-2003 *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals.*

xx. WARRANTY.

(a) Special Warranty. Manufacturer's standard form in which manufacturer agrees to repair or replace luminaries or components of luminaires and lamps that fail in materials or workmanship; corrode; or fade, stain, or chalk due to effects of weather, vibration, or solar radiation within specified warranty period.

Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

(1) Warranty Period for Luminaries. Five years from date of Substantial Completion.

The serial numbers for luminaires shall be listed and saved against the warranty sheet for each luminaire order. A copy of this list shall be submitted to the Engineer and the VTrans Traffic Shop upon completion and acceptance of work.

(2) Warranty Period for LED drivers. Minimum five years from date of Substantial Completion.

(3) Warranty Period for LED Lumen Depreciation. Lumen Depreciation shall not be more than 10 percent within the five year warranty period starting from date of Substantial Completion.

(4) Warranty Period for Metal Corrosion. Five years from

date of Substantial Completion.

- (5) Warranty Period for Color Retention. Five years from date of Substantial Completion.

xx. MANUFACTURE. Luminaire shall be the BetaLED (*LEDway IP*) series, Holophane (*LEDgends*) series, or LRL LED luminaire #SAT-96M series.

Luminaires shall include the following options as defined. Finite catalog numbers to be developed by the manufacturer and submitted with the Fabrication Drawing review process to ensure all options defined are properly incorporated into the product. Manufacturers indicated above are provided for sourcing purposes only. Products failing to meet specification requirements will not be accepted.

- (a) Luminaire shall be UL 1598 listed for installation in wet locations and direct spray environments.
- (b) Comply with IESNA testing and reporting procedures for reporting luminaire photometric performance.
- (c) Installation Environment. The luminaire shall be designed to provide 100,000 hours of life, applicable to the location and environment where fixture is installed (i.e. on a bridge structure, high humidity, vibration, etc.).
- (d) Metal Parts. Free of burrs and sharp corners and edges.
- (e) Sheet Metal Components. All materials shall be corrosion-resistant aluminum, unless otherwise indicated. Each component shall be formed or supported to prevent warping and sagging.
- (f) Housings. Rigidly formed, weather and light-tight enclosures that will not warp, sag, or deform in use. All surfaces shall be protected with an electrostatically applied polyester powder coating inside and out; corrosion-resistant passing 3000 hour salt spray test; the luminaire as a complete assembly shall be rated IP66. The EPA shall be less than 0.08 square meters (0.9 square feet). Provide filter/breather for enclosed luminaries.
- (g) Construction. The luminaire shall be modular to the extent that the optics package and power supply are separate and removable from the housing and that failure of any part thereof would not require total replacement of the luminaire. The optics package and the power supply shall be sealed against the entry of moisture and dirt where the branch circuit enters the housing.
- (h) Mounting. The housing shall be designed for slip-fit mounting to the end of the arm. The mounting system for the luminaires shall include two (2) hot-dipped galvanized steel clamp brackets which are secured by means of two (2) stainless steel mounting bolts on each bracket. This

adaptation point shall be designed for standard 2 inch (50 mm) Schedule 40 tubing. Each clamp shall have a stainless steel through bolt to prevent rotation of the luminaire. The Contractor shall coordinate with the mounting arm manufacturer to ensure proper positioning of the through bolt.

- (i) Thermal Management. Heat sink design and spacing shall provide required heat dissipation at the highest operating current but shall be arranged and oriented such that bird droppings and feathers from roosting birds cannot foul the airways and compromise the cooling efficiency. A self-cleaning heat sink design without requiring the use of hose spray is required by this application. The design of the luminaire shall provide the necessary heat dissipation to maintain the driver's case temperature to maximize the life expectancy of the driver to 100,000 hours.
- (j) Hardware Material. Unless otherwise noted, all hardware shall be stainless steel with nylon inserts for all nuts, etc.
- (k) Branch circuit wiring to the luminaire shall be via the mast arm tenon through the slip fit. Wiring shall be secured inside the luminaire with an integral wire clamp to prevent movement and abrasion.
- (l) The incoming AC line conductors (#12AWG or #10AWG) shall be terminated in a polarized plug/receptacle combination so that the luminaire may be locally de-energized and the plug removed without presenting a shock hazard or the potential for shorting the conductors together or to ground. The luminaire shall be designed to be removable once the plug is removed from the receptacle (any such maintenance shall normally be performed while the branch circuit connecting to the plug remains energized - the plug shall be weather-protected in case the luminaire cannot be replaced immediately).
- (m) Grounding lug connected to the housing shall be provided.
- (n) Luminaires shall be rated for operation over the range - 40°C to +60°C (-40°F to +140°F).
- (o) Performance. The combined operating life rating of optics package and power supply shall be 100,000 hours minimum, where end-of-life shall be taken as the point where lumen output has decreased to 70% of the initial value.
- (p) Plastic Parts. High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
- (q) Non-ornamental luminaires shall be classified with a maximum BUG rating of B2-U0-G2.
- (r) Reflecting surfaces shall have minimum reflectance as follows, unless otherwise indicated:

- (1) White Surfaces - 89 percent.
 - (2) Specular Surfaces - 90 percent.
 - (3) Diffusing Specular Surfaces - 85 percent.
- (s) Lenses and Refractors Gaskets. Use heat and aging-resistant gaskets to seal and cushion lenses in luminaire doors.
- (t) Luminaire shall be provided with the following:
- (1) Fixture to have anti-vermin protection.
 - (2) Ballast door and lens frame are each to be secured to housing via a 1.5 mm (1/16") galvanized safety cable. This cable shall be long enough as to not interfere with the opening and closing of any doors or covers.
 - (3) Luminaire safety cable is to be galvanized steel 3 mm (1/8") with two crimped ends with loops, a thread-locking agent, and split lock washers on all bolts.
 - (4) Wiring terminal block.
 - (5) Teflon, abrasion resistant, safety cable cover.

xx. LED DRIVER.

- (a) LED drivers used in the luminaires shall be of the luminaire manufacturer's specification, subject to the same operating requirements, quality assurance program, and terms of warranty as the luminaire.
- (b) Type. Switching-type with constant current output; commercial grade with a capacitor life rating of 100,000 hours or better at 63°C (145°F) case temperature. Other components with limited shelf life or subject to degradation over time shall not be used on the driver circuit board. Rated minimum operating life for the driver shall not be less than the operating life of the overall LED package measured to 24% depreciation of initial lumen output.
- (c) Input Voltage. LED drivers designed for multi-voltage input (120-277V) shall automatically select for the connected voltage or shall be clearly marked at the point of connection for the particular voltage.
- (d) Drivers shall be overload/overcurrent protected on the AC line side connection preferably with an electronic resettable device or a fuse; fuses shall be protected in tool-less, finger-safe holders and shall be replaceable without removing incoming power.
- (e) A shielded and replaceable surge protective device (rated

ANSI C62.41 Category C) shall be provided integral with the luminaire/driver package to dissipate transient voltages appearing on the AC input.

- (f) The LED optics package shall be designed to meet the lighting requirements as specified herein with a drive current no greater than 700mA, but shall be designed and capable of continuous operation within allowable temperature limits to meet the application requirements.
- (g) Operating Temperature Range. -40°C to +60°C (-40°F to +140°F).
- (h) The minimum MTBF shall be one million hours in accordance with Telcordia SR-322 performed by an independent laboratory at the operating current required by the application and at the maximum rating of the driver.
- (i) LED driver efficiency shall be 90% or higher with power factor greater than 90% at any drive current.
- (j) LED driver shall in compliance with FCC 47 CFR Part 15.

xx. LEDs.

- (a) Optics Package. Consisting of one or more LED modules or 'light bars', each comprised of multiple LEDs. The number of LED modules used shall be based on the required lumen output to achieve the project illumination design goals as shown in the Plans. The optics package with the required number of light bars shall also be rated with the housing for 3G vibration. The optics package (light bars) shall be rated IP66.
- (b) Operating Temperature Range. -40°C to +60°C (-40°F to +140°F).
- (c) Manufacturers of LEDs shall have been in the business for 15+ years, engaged in research, development, and marketing of LED wafers and shall have patents on these and related products.
- (d) LEDs used by the luminaire manufacturer shall be identified and direct-sourced from the manufacturer of the LED and shall be certified by the manufacturer of the luminaire as being the LED type and rating used in the manufacture and design of the photometric and thermal characteristics of the particular luminaire.
- (e) LEDs shall be color matched for all light bars on any given luminaire to a Correlated Color Temperature (CCT) of 4000K minimum, 6000K maximum with CRI of 70.
- (f) Consisting of one or more LED modules or 'light bars', each comprised of multiple LEDs connected such that individual LED failures may occur without affecting any other LEDs in the column and row where the failed LED occurred.

- (g) Quality control checks, specifications, and binning procedures used by the manufacturer of the luminaire shall be submitted along with the luminaire specification sheets and Fabrication Drawings.
- (h) Light Loss Factor. Calculated at 15 years (minimum 11 hours of operation each day) combining Light Lumen Depreciation (LLD) calculated at the maximum operating junction temperature, the Luminaire Dirt Depreciation (LDD), and an efficiency factor relating power supply degradation to light loss shall be greater than 22.5 percent.
- (i) LED Maximum Rated Junction Temperature. The overall design of the thermal package shall provide a temperature margin when operating at the maximum rated driver current in a 60°C (140°F) ambient temperature, not to exceed the maximum allowable LED junction temperature.

xx. FACTORY FINISHES. Manufacturer's standard paint applied to factory-assembled and factory-tested luminaire before shipping.

xx. INSTALLATION.

- (a) Luminaire Attachment. Fasten to roadway lighting pole arm with mounting bracket, thru bolt, and safety cable. Safety cable is to be looped around the cast bar at the rear for the housing and then both ends are to be secured to the arm with a bolt and a washer.

Adjust luminaries that require field adjustment or aiming until values shown in illuminance array are obtained.

Cover all chips and scratches on luminaire housings using a protective coating recommended by or provided by the manufacturer of the luminaire.

xx. CONNECTIONS. 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.

Use a thread-locking agent in all fasteners before installation.

xx. FIELD QUALITY CONTROL.

- (a) Inspect each installed fixture for damage. Replace damaged fixtures and components.
- (b) Tests and Observations. The contractor is responsible to verify normal operation of lighting units after installing luminaries and energizing circuits with normal power source. Contractor is required to provide a written report illustrating measured luminance levels in candela per square meter (foot-candles). Use meters that have been

calibrated within 12 months of date of the test. Testing procedure shall comply with IESNA LM-50.

- (c) The Contractor shall prepare a written report illustrating that the proposed fixtures meet the above requirements. Report shall include a review of the tests completed, all inspections, observations, and verifications indicating interpreted results. If adjustments are made to lighting system, retest to demonstrate compliance with standard.
- (d) Contractor to provide all manpower, equipment, lift truck, lane closures, etc. at no additional cost to demonstrate the installation complies with the Contract Documents.
- (e) Photometric performance of installed units shall meet or exceed those values noted above.

xx. METHOD OF MEASUREMENT. The quantity of Special Provision (Luminaire, LED) to be measured for payment will be the number of each, with photocell, connected both mechanically and electrically in the complete and accepted work.

xx. BASIS OF PAYMENT. The accepted quantity of Special Provision (Luminaire, LED) will be paid for at the Contract unit price for each. Payment will be full compensation for furnishing, transporting, handling, and installing the materials specified and for furnishing all labor, tools, equipment, and incidentals necessary to complete the work.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
900.620 Special Provision (Luminaire, LED)	Each