



18 MAR 2010

FROM: HQ AFCESA/CEOA
139 Barnes Drive Suite 1
Tyndall AFB FL 32403-5319

SUBJECT: **Engineering Technical Letter (ETL) 10-2: Light-Emitting Diode (LED) Fixture Design and Installation Criteria for Interior and Exterior Lighting Applications**

1. Purpose. This ETL provides technical guidance and criteria for specifying, designing, and installing LED luminaires for interior and exterior lighting applications at Air Force installations. This ETL does not apply to LED airfield lighting systems, including, but not limited to, taxiway, obstruction, runway edge, threshold, or approach lighting systems (consult ETL 09-12, *Use of Light-Emitting Diode (LED) Fixtures in Airfield Lighting Systems on Air Force Installations and Expeditionary Locations*).

This ETL replaces HQ AFCESA/CEN memo, *LED Parking Light Projects in FY10 Energy S/R&M Validation*, dated 3 September 2009.

Note: The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this ETL does not imply endorsement by the Air Force.

2. Application. Requirements in this ETL are mandatory. Any deviation from the contents herein requires approval from the Chief Electrical Engineer, HQ AFCESA/CEOA.

2.1. Authority:

- Air Force instruction (AFI) 32-1063, *Electrical Power Systems*
- Unified Facilities Criteria (UFC) 3-530-01, *Interior and Exterior Lighting and Controls*

2.2. Effective Date: Immediately

2.3. Intended Users:

- Major command (MAJCOM) engineers
- Base civil engineers (BCE)
- Base maintenance organizations
- All MAJCOM and base-level energy managers
- Contracting officers

2.4. Coordination:

- MAJCOM electrical engineers and energy managers

3. Referenced Publications.

3.1. Air Force:

- AFI 32-1063, *Electrical Power Systems*, <http://www.e-publishing.af.mil>
- ETL 09-11, *Civil Engineering Industrial Control System Information Assurance Compliance*, http://www.wbdg.org/ccb/browse_cat.php?o=33&c=125
- ETL 09-12, *Use of Light-Emitting Diode (LED) Fixtures in Airfield Lighting Systems on Air Force Installations and Expeditionary Locations*, http://www.wbdg.org/ccb/browse_cat.php?o=33&c=125

3.2. Joint:

- Unified Facilities Criteria (UFC) 3-530-01, *Interior and Exterior Lighting and Controls*, http://www.wbdg.org/ccb/browse_cat.php?o=29&c=4

3.3. Industry (also see Attachment 1):

- International Electrochemical Commission (IEC) 61543-1, *Residual Current-Operated Protective Devices (RCDs) for Household and Similar Use - Electromagnetic Compatibility*, 2005 edition
- Institute of Electrical and Electronics Engineers / American National Standards Institute (IEEE/ANSI) C62.42, *Guide for the Application of Component Surge-Protective Devices for Use in Low-Voltage (Equal to or Less than 1000 V (ac) or 1200 V (dc)) Circuits*, 2005 edition
- Underwriters Laboratories (UL) 1283, *Electromagnetic Interference Filters*
- UL 1449, *Surge Protective Devices*, 3rd edition

4. Acronyms and Terms.

μs	- microsecond
A/E	- architect/engineer
AC	- alternating current
AFI	- Air Force instruction
ANSI	- American National Standards Institute
ASTM	- American Society for Testing and Materials
BCE	- base civil engineer
C	- Celsius
CCT	- correlated color temperature
cd	- candela
DC	- direct current
DOE	- Department of Energy
Duv	- distance to the closest point on the Planckian locus on the CIE 1976 (u', v') diagram, with + sign for above and - sign for below the Planckian locus
EMI	- electromagnetic interference
EPA	- effective projected area
FCC	- Federal Communications Commission
HID	- high-intensity discharge

HQ AFCESA/CEN	- Headquarters, Air Force Civil Engineer Support Agency, Facility Energy Center
HQ AFCESA/CEOA	- Headquarters, Air Force Civil Engineer Support Agency, Engineer Support Branch
Hz	- hertz
IEC	- International Electrochemical Commission
IEEE	- Institute of Electrical and Electronics Engineers
IESNA	- Illuminating Engineering Society of North America
K	- kelvin
kA	- kiloamp
kHz	- kilohertz
kV	- kilovolt
LED	- light emitting diode
LLD	- lamp lumen depreciation
LLF	- light loss factor
MAJCOM	- major command
mW/nm	- milliwatt per nanometer
NEC	- National Electrical Code
NEMA	- National Electrical Manufacturers Association
NFPA	- National Fire Protection Association
NRTL	- nationally recognized testing laboratory
POE	- point of equipment
RFI	- radio frequency interference
RoHS	- restriction of hazardous substances
ROI	- return on investment
SSL	- solid state lighting
UFC	- Unified Facilities Criteria
UL	- Underwriters Laboratories
UV	- ultraviolet
V	- volt
VA	- volt-ampere
W	- watt

5. Background.

5.1. There has been confusion over whether UFC 3-530-01, *Design: Interior and Exterior Lighting and Controls*, paragraph 5-3.7, permits LED luminaires to be used in exterior applications. As the interpretive authority for UFC 3-530-01, the Chief Electrical Engineer for the Air Force, HQ AFCESA/CEOA, determined that the current UFC guidance only applies to LED luminaires used for:

- Exit signs
- General signage
- Traffic signals
- Step lighting
- Directional accent lights and other low-level lighting applications

5.1.1. The Chief Electrical Engineer has also determined LED luminaires are not permitted for exterior applications by UFC 3-530-01, Chapter 7. Only metal halide, induction, low-pressure sodium, or high-pressure sodium lamps are to be used in parking lots or area lighting.

5.1.2. The Chief Electrical Engineer has also determined LED luminaires are not permitted for any interior lighting systems as specified in UFC 3-530-01, Chapter 6.

5.2. Because of the need to consider new LED technology for lighting applications, supplemental guidance to UFC 3-530-01 for LEDs is provided in this ETL.

6. Interior LED Luminaire Applications. LED luminaires are not permitted for any interior facility lighting applications. **Exception:** Lighting for display cases or bulletin boards.

7. Existing Interior and Exterior LED Luminaire Installations.

7.1. To determine the reliability, maintainability, and appropriateness of LED technology for interior and exterior lighting systems, bases that have already installed LED luminaires before the September 2009 moratorium on LED installation shall provide quarterly reports that assess fixture performance.

7.2. The base energy manager shall prepare annual reports in the format provided in Attachment 2 that describes the LED luminaire system and performance. The report shall include, as a minimum, the following items:

- Description of the LED lighting system
- Type of LED fixture and manufacturer
- Photographs of LED luminaire installation
- Maintenance, repair, or replacement actions
- Operating environment, e.g., seasonal temperatures, rainfall, snowfall, thunderstorms
- Warranty claims
- Approximate number of operating hours
- Customer reviews/responses

7.3. The first annual report is due 1 June 2010 and continues thereafter through 1 June 2014, unless the requirement for an annual report is rescinded earlier by HQ AFCESA/CEOA. A copy of each report shall be sent to the MAJCOM electrical engineer or energy manager, HQ AFCESA/CEN, and the Chief Electrical Engineer, HQ AFCESA/CEOA.

8. New or Retrofit Exterior LED Luminaire Applications.

8.1. LED luminaires are not approved for residential housing applications. **Exception:** Street lighting projects approved in accordance with this ETL.

8.2. LED luminaires are not approved for airfield ramp, alert, security, or munitions area lighting due to interference with night-vision goggles operation.

8.3. LED luminaires are not approved for marine applications where low-pressure sodium lighting is specified because of the unknown effect on marine life.

8.4. Solar-powered or combination solar- and utility-powered LED luminaires are prohibited because of unacceptable battery installation and maintenance problems.

8.5. LED luminaires that require remote mounting of any component needed for its operation, such as ballasts, drivers, light engine electronics, or other controls, are not allowed. All components needed to make the fixture operational shall be integral to the fixture housing.

8.6. Retrofit conversion of LED lamps or LED lighting module inserts that have been designed and constructed to be used in existing high-intensity discharge (HID) luminaires—including metal halide, mercury vapor, or fluorescent fixture enclosures—are prohibited. New, complete-assembly LED luminaires shall be used.

Note: Retrofit project installations are defined as replacing existing luminaires with a new LED installation or inserting LED technology into existing fixture housings.

Exception: LED lighting module retrofits for exterior application in covered areas, such as a service station canopy, parking garage, or covered entrances that use existing fluorescent or HID enclosures, may be permitted on a case-by-case basis but require written approval from the Chief Electrical Engineer, HQ AFCESA/CEOA. The replacement LED fixtures should produce the same light footprint on the ground/task (foot candles) as the current fixture with a new lamp. The intent is not to claim lower wattage by reducing light output. Specifications and requirements contained in Attachment 1 apply and documentation of compliance shall be provided to HQ AFCESA/CEOA staffed through the installation and MAJCOM. In all cases, special sheet metal fabrication, forming, and caulking around the fixture and/or protrusions is prohibited.

8.7. Local area network (LAN), wireless, radio, modem, power line carrier, and other communication methods other than hard-wired switches for LED light fixture control shall meet requirements contained in ETL 09-11, *Civil Engineering Industrial Control System Information Assurance Compliance*, prior to installation.

8.8. If the previous subparagraphs 8.1 through 8.7 support pursuing an exterior LED fixture installation initiative then follow the process outlined in the following paragraphs; otherwise, follow guidance in UFC 3-530-01 for approved lighting technologies. The following LED fixture applications are approved and require no further analysis:

- Exit signs

- General signage
- Traffic signals
- Step lighting
- Directional accent lights and other low-level lighting applications

9. Exterior LED Project Consideration.

9.1. Prior to advertising any LED exterior lighting project, the base energy manager and MAJCOM electrical engineer or energy manager shall review the calculation methods, assumptions, and resulting justification for the proposed LED lighting project. Forward a copy of the MAJCOM-approved five-year return on investment (ROI) and 20-year life-cycle cost data to HQ AFCESA/CEN and the Chief Electrical Engineer, HQ AFCESA/CEOA.

9.2. LED exterior lighting project approval shall be based on a five-year payback (ROI). ROI shall be computed and approved by the MAJCOM electrical engineer or energy manager prior to awarding a contract to acquire LED lighting. If the investment does not have a positive ROI, or if there are other opportunities with a higher ROI, then the investment should not be undertaken. To calculate the ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio. The ROI formula is stated below:

$$\text{ROI} = \frac{\text{Gain from Investment} - \text{Cost of Investment}}{\text{Cost of Investment}}$$

9.3. Use of life-cycle cost software, such as the Building Life-Cycle Cost program (BLCC) and Economic Analysis Package (ECONPACK), is highly encouraged. These applications can be found at http://www.wbdg.org/tools/tools_cat.php?c=3. Analysis shall be based on equivalent HID luminaire installations. The 20-year life-cycle analysis shall be based on an assumed life for LED luminaires of five (5) years and HID fixtures of 15 years. Life-cycle cost analysis shall include, but is not limited to, sustainment, restoration, re-capitalization, operating (to include energy), and initial capital investment.

10. New Construction Exterior LED Application Criteria.

10.1. Design and Site Lighting System Performance Requirements.

10.1.1. All new exterior LED lighting installations shall incorporate a lighting design certified and accomplished by (1) an experienced registered professional engineer for contracted architect/engineer (A/E) lighting design services; or (2) a base electrical engineer familiar with lighting design and criteria contained in applicable AFIs, UFCs, and ETLs. All lighting designs, either by an A/E or base electrical engineer, shall comply with UFC 3-530-01 and Illuminating Engineering Society of North America (IESNA) standards.

10.1.1.1. The design engineer shall specify maximum and minimum uniformity ratios.

10.1.1.2. The design engineer shall specify spill light control (light trespass) maximum illuminance levels.

10.1.1.3. For contracted A/E services or construction projects, compliance with all requirements contained in this ETL shall be ensured by the contracting officer and approved by the BCE (or designated representative) and MAJCOM electrical engineer or energy manager prior to approving the lighting design and fixture submittals from the contractor, if applicable.

10.1.1.4. For lighting designs accomplished by base civil engineering, the base electrical engineer shall certify all requirements in this ETL have been met and forward the design package to the MAJCOM electrical engineer or energy manager for approval. The MAJCOM electrical engineer or energy manager shall send a copy of the approval action to HQ AFCESA/CEN and the Chief Electrical Engineer, HQ AFCESA/CEOA.

10.1.2. Field measurements shall be taken by the lighting design engineer (i.e. contractor, A/E, or base electrical engineer) after installation to verify uniformity and average lighting levels meet design estimates. Additional field measurements are required by Attachment 1.

10.1.2.1. For contracted A/E services or construction projects, copies of the field measurement reports shall be submitted to the contracting officer, BCE (or designated representative), MAJCOM electrical engineer or energy manager, and the Chief Electrical Engineer, HQ AFCESA/CEOA. The contractor shall make necessary corrections and modifications to the installation to insure compliance with this ETL.

10.1.2.2. For lighting designs accomplished by base civil engineering, the base electrical engineer shall forward copies of the field measurement reports to the MAJCOM electrical engineer or energy manager, and Chief Electrical Engineer, HQ AFCESA/CEOA.

10.2. LED Luminaire Technical Specification. LED fixture design, component specifications, submittals, and installation criteria shall comply with UFC 3-530-01, IESNA standards, and the requirements contained in Attachment 1.

10.3. Surge Protection Requirements. Three layers of surge protection shall be provided for LED installations. The first two layers of surge protection are required to be installed by the contractor during fixture installation. The third layer of surge protection is internal to the luminaire and provided by the fixture manufacturer.

10.3.1. Branch Circuit Protection (Distribution Panelboard) – Layer 1. Panelboards shall incorporate surge protection with advanced harmonic filtering complying with Underwriters Laboratories (UL) 1449, *Surge Protective Devices*, 3rd edition; UL 1283, *Electromagnetic Interference Filters*, and American National Standards Institute / National Fire Protection Association (ANSI/NFPA) 70, *National Electrical Code*. (ACT Communications 471 or 453 Series or equivalent surge protection devices are recommended.)

10.3.2. Point of Equipment (POE) Connection External to Luminaire – Layer 2.

10.3.2.1. Installed at a point closest to the luminaire, e.g., base of lighting pole.

10.3.2.2. Shall conform to IEC 61543-1, *Residual Current-Operated Protective Devices (RCDs) for Household and Similar Use - Electromagnetic Compatibility*, 2005 edition, and be listed by a nationally recognized testing laboratory (NRTL) to UL 1449, 3rd edition, as a Class II device.

10.3.2.3. Shall be designed to survive 500 repetitive strikes of (6 kV/1.2 x 50 microseconds, 3 kA/8x20 microseconds) waveforms at one-minute intervals with less than 10% degradation in clamping voltage. This combination waveform will have both current and voltage elements as defined in IEEE/ANSI C62.42, *Guide for the Application of Component Surge-Protective Devices for Use in Low-Voltage (Equal to or Less than 1000 V (ac) or 1200 V (dc)) Circuits*, 2005 edition.

10.3.2.4. Shall provide discrete protection between line-to-ground (L-G) and line-to-line (L-L).

10.3.2.5. Shall incorporate a remote LED indicator to show the status of the surge protector, installed external to the surge protector mounted inside the pole or junction box. It shall be visible without having to enter the light pole to know the surge protector status.

10.3.3. POE Connection Internal to Luminaire – Layer 3: Shall comply with Attachment 1.

11. Retrofit Construction Exterior LED Lighting Application Criteria.

11.1. Design and Site Lighting System Performance Requirements.

11.1.1. All exterior LED lighting retrofit installations shall incorporate a lighting design certified and accomplished by either (1) an experienced registered professional engineer for contracted A/E lighting design services; or (2) a base electrical engineer familiar with lighting design and criteria contained in applicable AFIs, UFCs, and ETLs. All lighting designs accomplished, either by an

A/E or base electrical engineer, shall comply with UFC 3-530-01 and IESNA standards.

11.1.1.1. Field measurements shall be taken by the lighting design engineer, i.e., contractor, A/E, or base electrical engineer, pre- and post-installation to verify uniformity and average lighting levels are within 15% of pre-installation lighting levels and as required by Attachment 1.

11.1.1.2. The design engineer shall specify maximum and minimum uniformity ratios.

11.1.1.3. The design engineer shall specify spill light control (light trespass) maximum illuminance levels.

11.1.1.4. For contracted A/E services or construction projects, copies of the field measurement reports shall be submitted to the contracting officer, BCE (or designated representative), MAJCOM electrical engineer or energy manager, and Chief Electrical Engineer, HQ AFCESA/CEOA. For construction projects, the contractor shall make necessary corrections and modifications to the installation to ensure compliance with this ETL.

11.1.1.5. For lighting designs accomplished by base civil engineering, the base electrical engineer shall forward copies of the field measurement reports to the MAJCOM electrical engineer or energy manager, and Chief Electrical Engineer, HQ AFCESA/CEOA.

11.2. LED Luminaire Technical Specification. LED fixture design, component specifications, submittals, and installation criteria shall comply with UFC 3-530-01, IESNA standards, requirements contained in Attachment 1, and the following:

11.2.1. Replacement LED luminaires shall be selected such that their installation at old fixture locations can be made without modifying any structural member, including roof penetrations, to accommodate retrofit installation. Electrical modifications and/or changes shall be compliant with the latest version of NFPA 70, NEC. The requirements of paragraph 8, "New or Retrofit Exterior LED Luminaire Applications," apply.

11.2.2. Special sheet metal fabrication, forming, and caulking around the fixture and/or protrusions is prohibited.

11.3. Surge Protection Requirements. Surge protection requirements shall be in accordance with paragraph 10.3 and subparagraphs.

12. Contracting Requirements.

12.1. The requirements contained in this ETL shall be incorporated into applicable contracting documents.

12.2. LED fixture manufacturers shall submit written certification that their luminaires comply with Attachment 1 and shall be included in the first submittal from the contractor. Incomplete and/or incorrect information is unacceptable and will result in the light fixture failing to meet Air Force requirements. The base energy manager shall provide a copy of the LED fixture manufacturer's certification to the MAJCOM electrical engineer or energy manager and the Chief Electrical Engineer, HQ AFCESA/CEOA.

13. Warranties. LED fixture construction and installation warranties shall be provided in accordance with Attachment 1 and the following:

13.1. The contractor shall install luminaires in accordance with the design engineer's and manufacturer's requirements and shall obtain written concurrence from the luminaire manufacturer that the installation is compliant with their requirements. The signed memo, including post-installation field measurements, shall become part of the warranty package and be included in the final deliverables to the contracting officer.

13.1.1. The LED luminaire warranties shall begin on the date of final acceptance of the installation by the contracting officer or designated representative, as executed by a DD Form 1354, *Transfer and Acceptance of DOD Real Property*.

13.1.2. The contractor shall provide to the contracting officer written documentation of its ability to satisfy a worst-case, catastrophic warranty claim. The documentation shall clearly disclose the country in which the factory of fixture origin is located and the name of the company or organization that owns the factory (including all parent companies and/or organizations and their respective countries of corporate citizenship).

14. Point of Contact.

14.1. The authority having jurisdiction waiver and interpretive authority for this ETL is the Chief Electrical Engineer, HQ AFCESA/CEOA. To reach the Chief Electrical Engineer, call DSN 523-6995 or commercial (850) 283-6995, email: AFCESA.CEO3333@afnsep.af.mil, or mail to 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32408-5319.

14.2. Recommendations for improvements to this ETL are encouraged and should be furnished to the Chief Electrical Engineer, HQ AFCESA/CEOA, 139 Barnes Drive, Suite 1, Tyndall AFB, FL 32408-5319, DSN 523-6352, commercial (850) 283-6352, e-mail AFCESAReachbackCenter@tyndall.af.mil.

14.3. HQ AFCESA/CEN e-mail: AFCESACEN.CorpMailbox@afnsep.af.mil

14.4. HQ AFCESA/CEOA e-mail: AFCESA.CEO3333@afnsep.af.mil

LESLIE C. MARTIN, Colonel, USAF
Director, Operations and Programs Support

- 3 Atchs
1. LED Technology Specification Information
 2. Existing LED Installation Report Format
 3. Distribution List

LED TECHNOLOGY TECHNICAL SPECIFICATION INFORMATION

PART 1 GENERAL

1-1 REFERENCES

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

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

ANSI C62.41.1-2002	IEEE Guide on the Surge Environment in Low-Voltage (1000V and less) AC Power Circuits
ANSI C62.41.2-2002	IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000V and less) AC Power Circuits
ANSI C82.SSL1	SSL Drivers (in ANSI development)
ANSI C136.31-2001	American National Standard for Roadway Lighting Equipment – Luminaire Vibration
ANSI C136.3-2005	American National Standard for Roadway Lighting Equipment – Luminaire Attachments
ANSI C62.45-2002	Recommended Practice on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits
ANSI C78.377-2008	Specifications for the Chromaticity of Solid State Lighting (SSL) Products

AMERICAN SOCIETY FOR TESTING AND MATERIALS INTERNATIONAL (ASTM)

ASTM B117-09	Standard Practice for Operating Salt Spray (Fog) Apparatus
ASTM G53	Standard Practice for Operating Light and Water Exposure Apparatus (Fluorescent UV – Condensation Type) for Exposure of Nonmetallic Materials

FEDERAL COMMUNICATIONS COMMISSION (FCC)

(FCC) Title 47,
Subpart B, Section 15 Class A Emission Limits for Electronic Noise

ILLUMINATING ENGINEERING SOCIETY OF NORTH AMERICA (IESNA)

DG-13-99	Selection of Photocontrols for Outdoor Lighting Applications]
G-1-03	Guideline on Security Lighting for People, Property, and Public Spaces
HB-9	IESNA Lighting Handbook
LM-64-01	Photometric Measurements of Parking Areas

LM-79-08	IESNA Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products
LM-80-08	IESNA Approved Method for Measuring Lumen Maintenance of LED Light Sources
RP-8	Standard Practice for Roadway Lighting
RP 33-99	Recommended Practice for Lighting for Exterior Environments
TM 15-07	Luminaire Classification System for Outdoor Luminaires
TM 16-05	Technical Memorandum on Light Emitting Diode (LED) Sources and Systems

INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)

IEEE C2	National Electrical Safety Code
IEEE STDSPCD1155	IEEE Standards Dictionary: Glossary of Terms & Definitions

INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC)

IEC 60529	Degrees of Protection provided by enclosures (IP Code)
IEC 60068-2-78	Environmental Testing - Part 2-78: Tests - Test Cab: Damp Heat, Steady State
IEC 60068-2-14	Environmental Testing. Tests. Test N. Change of Temperature

MILITARY STANDARDS

MIL-STD-220B	Method of Insertion Loss Measurement
--------------	--------------------------------------

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

NEMA 250	Enclosures for Electrical Equipment (1000 Volts Maximum)
NEMA C78.377	American National Standard for Specifications for the Chromaticity of Solid State Lighting (SSL) Products
NEMA C136.10	American National Standard for Roadway Lighting Equipment-Locking-Type Photocontrol Devices and Mating Receptacles - Physical and Electrical Interchangeability and Testing
NEMA ICS 2	Standard for Industrial Control and Systems: Controllers, Contactors, and Overload Relays Rated Not More than 2000 Volts AC or 750 Volts DC: Part 8 - Disconnect Devices for Use in Industrial Control Equipment
NEMA ICS 6	Standard for Industrial Controls and Systems Enclosures
WD 7-2000	NEMA Guide Publication: Occupancy Motion Sensors

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 70 National Electrical Codes (NEC)

UNDERWRITERS LABORATORIES (UL)

UL 1283	Electromagnetic Interference Filters
UL 1310	Standard for Safety Class 2 Power Units
UL 1449	Surge Protective Devices
UL 1598	Standard for Luminaires
UL 773	Standard for Plug-In Locking Type Photocontrols for Use with Area Lighting
UL 773A	Nonindustrial Photoelectric Switches for Lighting Control
UL 198M	Standard for Mine-Duty Fuses (2003; Rev through Oct 2007)
UL 8750	Standard for Light Emitting Diode (LED) Equipment for Use in Lighting Products

1-2 DEFINITIONS

Unless otherwise specified or indicated, electrical and electronics terms used in these specifications, and on the drawings, shall be as defined in IEEE STDSPCD1155.

- a. Useful Life - the operating hours before reaching 70% of the initial rated lumen output point with no catastrophic failures under normal conditions.
- b. Correlated Color Temperature – a visible light characteristic of comparing a light source to a theoretical, heated black body radiator (measured in degrees Kelvin).
- c. Effective Projected Area (EPA) - the wind loading of the fixture.
- d. International Protection (IP) Rating – delineates the level at which foreign objects and water can intrude inside a device.
- e. Restriction of Hazardous Substances (RoHS) - products that are RoHS compliant do not contain any of the following materials: lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (Cr6+), polybrominated byphenyls (PBB), and polybrominated byphenyl ether (PBBE).

1-3 SUBMITTALS

Government approval is required for the following:

- a. Shop drawings.
- b. Certified lighting design.

- c. IESNA LM-79 report on manufacturer's standard production model luminaire to include:
- Testing agency, report number, date, manufacturer's name, catalog number, LED driver, drive current, ambient temperature
 - Luminaire efficacy (lumens/watt), minimum light output, zonal lumen density
 - Color qualities (CCT, CRI, chromaticity)
 - ANSI C78.377 Duv
 - Electrical measurements (input voltage, input current, input power (watts))
 - Spectral Distribution over visible wavelengths (mW/nm)
 - Absolute intensity candlepower (cd) summary table
 - Isocandela plot
 - Luminance summary table
 - Illuminance – cone of light plot
 - Illuminance – isofootcandle plot
 - Illuminance – roadway isofootcandle plot (if streetlight)
 - Picture of sample
 - IES file
- d. IESNA LM-80 report on LED package, array, or module to include:
- Testing agency, report number, date, type of equipment, and LED light source being tested.
 - All data required by IESNA LM-80.
 - Documentation shall be provided that demonstrates the LED manufacturer's maximum junction temperature for the designed life (10 years) shall not be exceeded.
 - Test laboratories shall be either National Voluntary Laboratory Accreditation Program (NVLAP) -accredited for solid-state lighting testing as part of the Energy-Efficient Lighting Products laboratory accreditation program or one of the qualified labs listed on the DOE SSL web site (http://www1.eere.energy.gov/buildings/ssl/test_labs.html).
- e. Computer-generated photometric analysis of proposed maintained illuminance values of the lighting installation using LLF value of 0.85 and LLD value of 0.85 for submittal only. Project application-specific LLF and LLD values shall be set by the design engineer for each project. Submittal should include the following requirements:
- Horizontal illuminance measurements at finished grade. Spacing between computer calculation points shall be 5 feet.
 - Vertical illuminance measurements at 5-foot intervals above finished grade.
 - Minimum footcandle level.
 - Maximum footcandle level.
 - Average maintained footcandle level.

- Maximum and minimum ratio (horizontal).
- f. Product compliance certification:
- Documentation from the LED manufacturer shall be provided showing maximum current allowed and where the current output from the driver is not what is flowing into the LEDs. A schematic with calculations shall be provided to show what driver current does flow to the LEDs. Written certification that an LED's input current is not greater than the rated current from the LED manufacturer.
 - Certified manufacturer compliance with IESNA documents.
- g. Certification that fixture meets recyclability requirements.

1-4 LUMINAIRE DRAWINGS

Include dimensions, effective projected area (EPA), accessories, and installation and construction details.

1-4.1 DESIGN DATA FOR LUMINAIRES

- a. Distribution data according to IESNA classification type as defined in IESNA HB-9.
- b. Amount of shielding on luminaires.
- c. Provide safety certification and file number as required for the luminaire family that shall be listed, labeled, or identified per the National Electric Code (NEC). Applicable testing bodies are determined by the Occupational Safety and Health Administration (OSHA) as nationally recognized testing laboratories (NRTL) and include CSA (Canadian Standards Association), ETL (Edison Testing Laboratory), and UL (Underwriters Laboratory).

1-4.2 STANDARD PRODUCTS

Provide materials and equipment that are products of manufacturers regularly engaged in the production of products that are of equal material, design, and workmanship. The manufacturer's products shall have been in satisfactory commercial or industrial use for two (2) years prior to bid opening. The two-year period shall include applications of equipment and materials under similar circumstances and of similar size. The manufacturer's products shall have been on sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two-year period. Where two or more items of the same class of equipment are required, these items shall be products of a single manufacturer. Component parts of the item need not be the products of the same manufacturer unless stated in this section.

1-4.2.1 Material and Equipment Manufacturing Date

Products manufactured more than one (1) year prior to date of delivery to site shall not be used, unless specified otherwise.

1-4.3 ENERGY EFFICIENCY

Comply with National Energy Policy Act and Energy Star requirements for lighting products. Submit documentation for Energy Star qualifications for equipment provided under this section.

1-4.4 WARRANTY

LED luminaires and replacement lamps available today claim long life, e.g., 50,000 hours or more, which exceeds the life ratings of nearly all other light sources (except for some electrodeless sources). These claims are based on the estimated lumen depreciation of the LED used in the product and often do not account for other components or failure modes. Projected life of LED luminaires is a key component to payback scenarios in project evaluations; therefore, it is critical that products perform as promised and anticipated. Since life claims provided by suppliers is typically 50,000 hours or greater and the first cost of exterior LED luminaires may be significant, warranties shall include product performance as claimed in terms of useful life. Life claims by LED luminaire manufacturers shall take into account the whole system, not just the LEDs. One of the key lessons learned from early market introduction of compact fluorescent lamps is that long-life claims need to be credible and backed up with adequate manufacturer warranties.

The equipment items shall be supported by service organizations that are reasonably convenient to the equipment installation in order to render satisfactory service to the equipment on a regular and emergency basis during the warranty period of the contract.

Note: On-site replacement includes transportation, removal, and installation of new products.

- a. LED manufacturer shall provide a written five-year on-site replacement “finish” warranty for luminaires. Finish warranty shall include warranty against failure or substantial deterioration such as blistering, cracking, peeling, chalking, or fading.
- b. LED manufacturer shall provide a written five-year on-site replacement warranty for defective or non-starting power supply unit and LED source assemblies, which includes, but is not limited to, LED package, LED arrays, LED modules, LED die, encapsulate, and phosphor.
- c. LED manufacturer shall provide a written ten-year on-site replacement warranty for any LED source assembly, package, array, or module, which does not

include the power supply, if 15% of the individual LEDs in that assembly, package, array, or module fails to illuminate.

- d. The LED manufacturer warranty period shall begin on date of final acceptance, as executed by a DD Form 1354, *Transfer and Acceptance of DOD Real Property*. Contractor will provide the contracting officer with signed warranty certificates prior to final payment.

PART 2 PRODUCTS

2-1 LUMINAIRES

Provide luminaires as indicated and complete with LED light source and power supply unit. Details, shapes, and dimensions are indicative of the general type desired but are not intended to restrict selection to luminaires of a particular manufacturer. Luminaires of similar designs, light distribution and brightness characteristics, and of equal finish and quality will be acceptable as approved.

2-1.1 GENERAL REQUIREMENTS

- a. Luminaire shall be UL-listed for wet locations and wiring cavity shall be field-accessible for service or repair needs.
- b. Luminaire shall be full cutoff or fully shielded as defined by IESNA RP-8.
- c. Luminaires shall meet IESNA RP-8 guidelines for luminance and veiling luminance.
- d. The rated voltage and rated power in watts and volt-ampere shall be permanently marked inside each unit.
- e. Optical system for roadway and area luminaires, including the driver, shall be sealed and rated for IP65 as defined in IEC 60529. Wiring compartments shall be IP20 compliant, but individual internal electronic components must be rated at a minimum of IP54.
- f. Luminaires shall be fully assembled and electrically tested prior to shipment from factory.
- g. For all mast-arm-mounted luminaires, a wildlife shield shall be included on the fixture to prevent wildlife access.
- h. Color of the luminaire shall be bronze unless specified otherwise.
- i. The coating shall be capable of surviving ASTM B117 salt fog environment for 500 hours minimum without blistering or peeling.

- j. The coating shall demonstrate gloss retention of greater than or equal to 90% for 1000 hours' exposure QUV test per ASTM G53 UVB313, 4 hour UV-B 60 °C/4 hour condensation 50 °C.
- k. The luminaire shall have been certified compliant with ANSI C136.31 having been subjected to 100,000 cycles of 2 Gs at the resonant frequency of the luminaire applied at the center of gravity of the luminaire on three primary axes without damage to the luminaire. The luminaire shall be fully functional upon completing the test.
- l. The luminaire shall be fully functional after testing for thermal shock according to IEC 60068-2-14.
- m. The luminaire shall be fully functional after testing for damp heat, steady state, high humidity, and high temperatures according to IEC 60068-2-78.
- n. Luminaire arm bolts shall be 304 stainless steel or zinc-plated steel.
- o. If a lens not integral to the luminaire is used, optical enclosure (lens/window) shall be constructed from clear and UV-resistant acrylic or tempered glass.
- p. At least 80% of the luminaire material by weight shall be recyclable at manufacturer's stated end of life.
- q. Luminaires shall incorporate modular electrical connections and constructed to allow replacement of all or part of the optics, heat sinks, power supply units, and electrical components using only a simple tool, such as a screwdriver.
- r. Luminaires shall have a nameplate bearing the manufacturer's name, address, model number, date of manufacture, and serial number securely affixed in a conspicuous place; the nameplate of the distributing agent will not be acceptable.
- s. The luminaire fixture weight and effective projected area shall not exceed the poles requirements for wind loading.
- t. Roadway and area mast-arm-mounted luminaires shall have an integral tilt adjustment of $\pm 6^\circ$, ANSI C136.3.
- u. Roadway, parking, and area lighting luminaires shall have an option to accept a standard, locking-type, NEMA-type photo control receptacle conforming to NEMA C136.10 and rated no less than 1800 VA.

2-1.2 WIRING

All factory electrical connections shall be made using crimp, locking, or latching style connectors. Twist-style wire nuts and tap-style stripless connectors are not acceptable.

2-1.3 POWER SUPPLY UNITS

- a. Driver shall be protected against damage due to either an open circuit or short circuit fault condition on the driver output. The driver shall resume normal operation when the fault is removed.
- b. Over-temperature protection shall be provided and cut-off output power if case temperature limit is exceeded.
- c. Minimum efficiency of 85%.
- d. The maximum drive current to the LEDs shall not exceed that recommended by the LED manufacturer. Documentation from the LED manufacturer shall be provided showing maximum current allowed and where the current output from the driver is not what is flowing into the LEDs. A schematic with calculations shall be provided to show what driver current does flow to the LEDs.
- e. Rated to operate between -40 °C to +50 °C.
- f. Maximum case temperature and measurement location shall be clearly marked on the driver case.
- g. Designed to operate on voltage system to which they are connected. Fluctuations in line voltage up to 15% shall have no visible effect on the luminous output.
- h. Drivers shall be UL 8750 compliant.
- i. Operating frequency: 50/60 Hz \pm 5%
- j. Power factor (PF): \geq 0.95
- k. Total current harmonic distortion (THD) for current: \leq 15%
- l. Comply with FCC 47 CFR Section 15 non-consumer RFI/EMI standards.
- m. Reduction of hazardous substances (RoHS) compliant.

2-1.4 LED LIGHT SOURCE (LIGHT ENGINE)

- a. LEDs (not the luminaire) shall have a minimum efficacy of 80 lumens per watt.

- b. Where LEDs are connected in series and a single LED failure results in greater than 5% light loss of the overall luminaire output, a bypass circuit shall be utilized. This bypass circuit shall allow the remaining LEDs in the series circuit to remain powered.
- c. Thermal management shall be passive by design and shall consist of heat sinks with no fans, pumps, or liquids.
- d. Correlated color temperature (CCT) shall be between 4500 K to 6000 K.
- e. Color rendering index (CRI): ≥ 70 at the selected lamp's CCT.

2-2 ELECTRICAL SYSTEM

2-2.1 SURGE PROTECTION

- a. The luminaire manufacturer shall provide surge protection on each luminaire and certify that it has been tested in accordance with ANSI/IEEE C62.41.1, category C2 medium exposure, common mode and normal mode.
- b. Metal oxide varistors (MOV) core diodes shall not be rated more than 130% of maximum fixture voltage.
- c. Ten (10) repetitive strikes (0.5 μ s x 100 kHz, 0.5 kA 6 kV @ 12 ohm, ring wave) each mode.
- d. Five (5) repetitive strikes (8x20 μ s, 10 kV 5 kA @ 2 ohm, combination wave) differential mode.
- e. Five (5) repetitive strikes (8x20 μ s, 10 kV 0.83 kA @ 12 ohm, combination wave) common mode.
- f. Surge protection device shall have integral fuse and thermal protector so that failure of the surge protection device will result in the disconnection of power to the remainder of the luminaire, resulting in an outage.

2-2.2 DAYLIGHTING CONTROLS

All exterior parking lot, drive, and front aisle areas shall be controlled with a combination photocell plus time switch control system that allows automatic on and off based on daylighting plus timed off after expected parking lot activity ends. Photocell switch is used to energize all luminaires at dusk and to switch off any security lighting left on overnight by time switch.

2-2.3 PHOTOCCELL SWITCH

UL 773 or UL 773A, hermetically sealed cadmium-sulfide or silicon diode type cell rated for the appropriate fixture voltage, 60 Hz with either single-throw contacts or single pole double-throw (SPDT) contacts for mechanically held contactors rated 1000 watts designed to fail to the "OFF" position. Switch shall turn on at or below 32 lux (3 footcandles) and off at 43 to 107 lux (4 to 10 footcandles). A time delay shall prevent accidental switching from transient light sources. Provide a directional lens in front of the cell to prevent fixed light sources from creating a turnoff condition.

Note: Programming for the timeclock shall be maintained either by a similar mechanism as the clock and for a similar time requirement, or that it be stored in non-volatile memory.

Provide switches that:

- a. Are reduction of hazardous substances (RoHS) compliant.
- b. Utilize an ambient light-sensing technology which inherently minimizes the contribution of typical high-power LED light sources to the sensed light level.
- c. Have a rated life expectancy of 90,000 hours' continuous operation.
- d. Incorporate remote photocell switch in a cast weatherproof housing with adjustable window slide used to energize all luminaires conforming to NEMA C136.10 (3-prong, twist lock) and rated 1800 VA minimum.
- e. Are in a UV stabilized polycarbonate housing with swivel arm and adjustable window slide, rated 1800 VA minimum.

2-2.4 TIME SWITCH

Astronomic dial type or electronic type, arranged to turn "ON" at sunset and turn "OFF" at predetermined time between 8:30 p.m. and 2:30 a.m. or sunrise, automatically changing the settings each day in accordance with seasonal changes of sunset and sunrise. Provide switch rated at the appropriate fixture voltage having automatically wound spring mechanism or capacitor to maintain accurate time for a minimum of seven hours following power failure. Provide time switch with a manual on-off bypass switch. Housing for the time switch shall be surface mounted, minimum NEMA 3R, enclosure conforming to NEMA ICS 6.

2-2.5 DAY BURNER PROTECTION

The luminaire shall be furnished with integral protection against accelerated wear due to daytime operation caused by the failure of the photo control or time clock normally used to control the luminaire. This protection shall:

- a. Consist of an integral back-up control device which will automatically detect the failure of the primary control and force the LEDs off during the day. The back-up control shall be compatible with any photo-control or time clock and shall incorporate a means for visibly indicating that the luminaire control requires service. Such notification shall be clearly visible in daylight.
- b. Not prevent manual overrides during the day or in any other way affect the normal function of the luminaire or primary controls.
- c. Be rated for use in ANSI C62.41.1 Category C environments.

Note: Dayburner protection methods based on timely notification of the outage via LAN, wireless LAN, or radio systems require HQ AFCESA/CEOA approval and shall follow compliance guidance outlined in ETL 09-11, *Civil Engineering Industrial Control System Information Assurance Compliance*.

2-3 OPTIONAL CONTROLS

2-3.1 CURFEW CONTROL

Optional controls provided in addition to the photocell switch plus time switch control system include after-hours dimming control which reduces light levels to approximately 50% of full lumen output at a predetermined time (after expected parking lot activity ends). Controls shall be designed to fail to the "OFF" position.

2-3.2 OCCUPANCY SENSOR CONTROLS

NEMA WD 7-2000, UL 773A. Provide passive infrared or microwave sensor with 360° coverage, time delay that can be adjusted from 30 seconds to 30 minutes, and designed to fail to the "ON" position. Sensors shall be located to achieve coverage of indicated areas. Coverage patterns shall be derated as recommended by manufacturer based on mounting height of sensor and any obstructions such as trees. Do not use gross-rated coverage in manufacturer's product literature. Sensors integral to the luminaire shall be provided by luminaire manufacturer.

- a. Infrared: Integral to the luminaire. Detect occupancy by changes in infrared energy within a coverage area and shall be capable of operating between -40 °C to +50 °C.
- b. Microwave: Integral to luminaire. Detect occupancy by transmitting electromagnetic energy into a coverage area, receiving direct and reflected energy, and monitoring frequency shift between transmitted and received signals. When more than one device is used in an area, devices shall operate on different frequencies. Provide for selective filtering by the sensor to minimize

nuisance tripping due to interference from radar or other sources of electronic interference.

2-3.3 DIMMING

- a. LED luminaires shall be capable of operating at full power and a minimum of one reduced power level plus off. The reduced power level shall be in the range of 30% to 70% power reduction. A reasonably uniform level of illuminance shall be maintained by the luminaire when it is set at both full and reduced power level.
- b. The dimming means shall not significantly impact the expected life of any component in the luminaire. If the dimming method used (e.g., switching off a portion of the LEDs or switching off one driver to reduce the light level) will result in one portion of the light engine to have longer run time per day than another portion then the longest run time expected per day shall be used.

EXISTING LED INSTALLATION REPORT FORMAT

1. Report date:
2. Base:
3. Description of the LED lighting system (parking, area, street lighting):
4. Photographs of LED installation:
5. LED fixture information:
 - a. Manufacturer:
 - b. Model:
 - c. Wattage of fixture:
 - d. Operating voltage:
 - e. Number of fixtures:
 - f. Estimated number of operating hours:
6. Maintenance, repair, or replacement actions (number replaced or repaired, number under warranty, and brief description of work accomplished):
7. Operating environment (include weather-related information such as seasonal temperatures, rainfall, snowfall, thunderstorm activity, etc., and any effect on operation or longevity of the LED luminaire):
8. Customer reviews/feedback, if applicable:
9. Base energy manager information:
 - a. Name:
 - b. E-mail address:
 - c. Phone:

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Defense Commissary Agency (1)	AAFES (1)
Design and Construction Division	ATTN: RE-C
2250 Foullois St., Suite 2	PO Box 660202
Lackland AFB, TX 78236	Dallas, TX 75266-0202

SPECIAL INTEREST ORGANIZATIONS

Information Handling Services (1)	Construction Criteria Base (1)
15 Inverness Way East	National Institute of Bldg Sciences
Englewood, CO 80150	Washington, DC 20005