LUNA
Technical Requirements
Version 1

Draft 2

Released for Comment: September 13, 2021

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Foreword

About the DLC

The DLC is a non-profit organization improving energy efficiency, lighting quality, and the human experience in the built environment. We collaborate with utilities, energy efficiency programs, manufacturers, lighting designers, building owners, and government entities to create rigorous criteria for lighting performance that keeps up with the pace of technology. Together, we're creating solutions for a better future with better lighting.

The DLC Solid-State Lighting (SSL) Technical Requirements define product performance requirements for commercial and industrial lighting products listed on the DLC SSL Qualified Products List (QPL). This list is used by DLC member programs across the US and Canada to designate SSL products eligible for energy efficiency incentives and rebates. Similarly, the DLC Networked Lighting Controls (NLC) Technical Requirements define requirements for commercial and industrial networked lighting control systems on the DLC NLC QPL; and the Horticultural Lighting Technical Requirements define requirements for LED lighting on the DLC Horticultural Lighting QPL for controlled environment agriculture. The energy efficiency programs that use these lists play a pivotal role in the replacement of incumbent lighting technologies with better performing and more energy efficient solutions to help their customers save energy and meet carbon reduction goals.

In addition to energy efficiency programs sponsored by electric utilities and state and provincial governments, the DLC's SSL QPL and Technical Requirements are used by multiple U.S. government facilities specifications. The General Services Administration's (GSA) P100 Facilities Standards for the Public Buildings Service requires LED luminaires to be qualified to DLC SSL Premium and the Department of Defense Unified Facilities Criteria requires that LED roadway luminaires be DLC listed. In addition, the Federal Energy Management Program (FEMP) requires that indoor troffers, linear ambient, and high bay luminaires meet the product qualification criteria listed in Table 4.4. of DLC SSL V5.0.

This document lists supplemental requirements for a classification of qualified outdoor commercial and industrial luminaires that not only meet the SSL V5.1 requirements for energy efficiency and lighting quality, but also have attributes that help limit light pollution, sky glow, and light trespass. LUNA qualified products will help cities and communities meet dark sky policies and ordinances; will help specifiers fulfill the light pollution and trespass requirements in LEED and WELL; and will help projects following the application guidance in the Joint IES-IDA Model Lighting Ordinance (MLO). Because LUNA qualified luminaires meet DLC requirements for energy efficiency, rebates and incentives are available from DLC member efficiency programs.

Limits of this Document

LUNA designated products that meet the Technical Requirements defined in this document will help limit light pollution, sky glow, and light trespass when used appropriately. This document is not intended

to provide application design guidance, nor to replace good lighting design practices. This document only contains requirements for outdoor products within the scope of the LUNA program, which does not include some types of outdoor lighting products. For example, floodlights or amber lights may be necessary and appropriate for some outdoor projects, even though these products are not included in the LUNA requirements at present. Furthermore, a floodlight, which does not have a LUNA qualification pathway, could yield desirable results when aimed down at the ground, but undesirable results when aimed improperly up at the sky or into windows on an adjacent property. Products such as floodlights, for which appropriate application-specific design is essential for avoiding light pollution, are not included in the LUNA requirements at present, but are eligible for listing under the SSL V5.1 requirements.

When installing the types of products described above, appropriate project design and application is essential to avoid over-lighting and to achieve relatively low sky glow and light trespass. Design and application guidance is available from resources such as the Illuminating Engineering Society (IES), which offers many application documents that address light pollution, including the Joint IES-IDA Model Lighting Ordinance (MLO), ANSI/IES LP-2-20, LP-10-20, LP-11-20, and RP-33-14 (soon to be replaced by RP-43). This document is not intended to supersede these resources. The DLC recommends that, when possible, a qualified lighting professional assist in designing and achieving a complete project that minimizes light pollution.

Any policies or regulations addressing outdoor lighting and referring to LUNA qualified products should recognize that while products that meet the specific requirements in this policy will help to mitigate light pollution, additional DLC SSL outdoor lighting products are also available for use on the DLC SSL QPL. These non-LUNA products can be used to mitigate light pollution by applying appropriate design solutions.

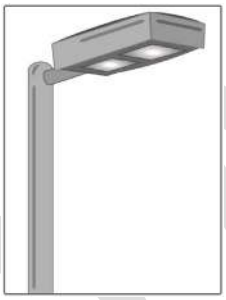
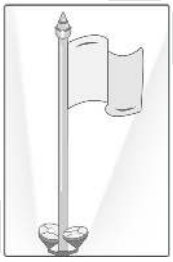
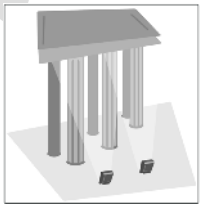
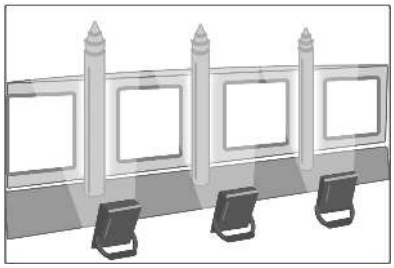
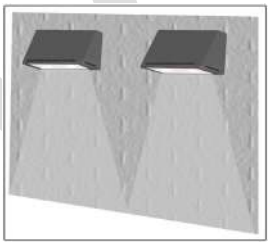
Any policies or regulations referring to LUNA qualification should consider including language such as the following:

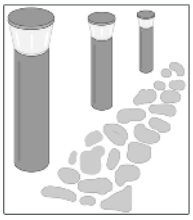
> **DLC LUNA qualified outdoor commercial and industrial lighting products shall be used when feasible. Products not DLC LUNA qualified may also be used when the designer deems them necessary to meet project design objectives.**

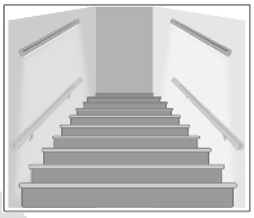
Scope of LUNA Requirements

Table 1 provides an overview of products that are in scope and out of scope of the LUNA Version 1 requirements. This is not a comprehensive list of products eligible and ineligible for LUNA; **Table 2** provides a more complete list. Floodlights, replacement lamps, and retrofit kits are not included in LUNA because these products require careful project design to mitigate light pollution. Project-level application design is beyond the scope of a list of qualified products. Luminaires for parking garages, stairwell/passageway, and tunnels are not included because uplight is typically blocked by the supporting structure, uplight intentionally lights the ceiling of the structure, and most light is contained within the structure. A complete list of eligible SSL Primary Use Designations (PUDs) is listed on the DLC website here.

Table 1: Outdoor luminaires included in and not included in LUNA

Included in LUNA V1		Not Included in LUNA V1	
Pole/Arm-Mounted Area and Roadway Luminaires		Floodlights	  
Pole/Arm-Mounted Decorative Luminaires			
Full-Cutoff Wall-Mounted Area Luminaires		Replacement Lamps and Retrofit Kits	

Included in LUNA V1	
Canopy	
Bollards	

Not Included in LUNA V1	
Parking Garage	
Stairwell	
Tunnel	

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Introduction

The DLC LUNA Technical Requirements are designed to mitigate negative impacts of outdoor lighting at night. By establishing requirements and reporting standards on light distribution, spectral characteristics, and controllability, LUNA will identify energy efficient luminaires that minimize light pollution, provide appropriate visibility for people, and limit negative impacts to the environment.

Feedback received and key changes from Draft 1

The DLC received 34 comments on the Draft 1 LUNA *Introduction* section during the first comment period. After careful assessment of stakeholder feedback, modifications were made within Draft 2 as described below. The bullets below describe the general feedback received and the sub-bullets describe how the DLC incorporated these changes into Draft 2.

- *Disclaimers are needed.*
  - The DLC clarified that the Technical Requirements are not an application design document. An application design that mitigates light pollution might include non-LUNA products. The LUNA qualification is not intended to be used in place of expert designers. LUNA is not a Model Lighting Ordinance (MLO) like the IES/IDA MLO. To address concerns, a foreword was added to clarify the limits and scope of this document.
- *The requirements should include a table of references to all standards.*
  - A table of references was added to the end of this document. Links to all references will be included with final publication of this document.
- *Additional general comments were received that applied to the LUNA program in general, but not specifically to this document.*
  - These comments will be considered in future plans for the LUNA program.

Goals of LUNA

The DLC LUNA requirements are intended to mitigate negative impacts of outdoor lighting at night by establishing luminaire performance specifications with the following goals.

- **Minimize lighting energy use**. Baseline efficacy thresholds of DLC SSL V5.1 combined with additional dimming and control requirements ensure efficient use of lighting energy, which will help efficiency programs meet their savings goals and end users reduce operational costs. At the same time, because of the high priority of minimizing light pollution, LUNA provides efficacy allowances to reduce light trespass with shielding.
- **Minimize light pollution**. New LUNA requirements for light distribution, spectral characteristics, and dimming control will decrease the light scattered into the atmosphere so that light trespass and sky glow are reduced, resulting in darker skies and more controlled illumination to support wildlife, stargazers, and astronomers.
- **Provide appropriate visibility for people**. The DLC SSL V5.1 requirements for spectral quality, with additional reporting of BUG rating, spectral power distribution, and intensity distribution,

allow the selection of the right product for each application so that installations meet recommended practices and voluntary guidelines.

The DLC LUNA Qualification and Logo

Products with the LUNA qualification (referred to as LUNA products) will be listed on the DLC Solid-State Lighting Qualified Products List. LUNA products can be either DLC Standard or DLC Premium, and will be eligible to use the DLC LUNA logo, which will be released with the final Technical Requirements. As with other DLC logos, all stakeholders must use the DLC logos and trademarks consistently and in compliance with published guidelines in all communication and marketing materials.

An application for LUNA qualification may require the submission of additional independent test reports (ITRs) which would be subject to the existing ITR fee consistent with the current V5.1 application fees. The DLC also intends to establish a per product listing fee. The LUNA listing fee will cover the costs of additional application review, as well as cost of creating, developing, and hosting the LUNA program.

Eligibility

Only outdoor luminaires that fall into the Primary Use Designations (PUDs) listed in **Table 2** will be eligible for LUNA qualification under Version 1. At this time, replacement lamps and retrofit kits are not eligible for LUNA because their lighting distributions are highly dependent on application and installation. Specialty designation hazardous luminaires are eligible for LUNA qualification with an exemption from the dimming requirements. Single product applications seeking LUNA qualification cannot include LUNA-ineligible variations.

Aimable luminaires, whether floodlights or area lighting with tiltable mounting brackets, may increase sky glow, discomfort glare, and light trespass, which are undesirable lighting qualities from both a light pollution perspective and for typical use cases. Therefore, floodlight-style PUDs and area/roadway/decorative PUDs with mounting brackets that allow tilt angles of more than +/- 10 degrees are not eligible for LUNA qualification. The 10-degree tilt will allow these luminaire types to be aligned parallel with the roadway surface.

Table 2: DLC SSL Primary Use Designations (PUDs) eligible for Version 1 LUNA qualification

Primary Use Letter	Primary Use Designations Eligible for LUNA Qualification
A	Outdoor Pole/Arm-Mounted Area and Roadway Luminaires
B	Outdoor Pole/Arm-Mounted Decorative Luminaires
C	Outdoor Full-Cutoff Wall-Mounted Area Luminaires
E	Bollards
G	Fuel Pump Canopy Luminaires
n/a	Specialty: Hazardous Area Lighting
	Specialty: Hazardous Outdoor Pole/Arm-Mounted Area and Roadway Luminaires
	Specialty: Hazardous Wall Mounted Luminaire
	Specialty: Canopy Lighting
	Specialty: Directional Fuel Pump Canopy Luminaires
	Specialty: Transportation

Definitions

The following terms are used by the DLC in the LUNA policy documents and/or application process:

- **Continuous dimming**: A lighting control strategy that varies the light output of a lighting system over a continuous range from full light output to a minimum light output without flickering in imperceptible steps. (NEMA LSD-64-2019)
- **Light pollution**: The combination of all the adverse or obtrusive effects of electric light that produces artificial sky glow including:
    - Unnecessary, unwanted, or wasted light
    - Light that damages or degrades the nighttime environment
    - Light that negatively impacts humans and other species (ANSI/IES LP-11-20)
- **Light trespass**: The encroachment of light, typically across property boundaries, causing annoyance, loss of privacy, or other nuisance. Also called spill light or obtrusive light. (ANSI/IES LS-1-20)
- **Rayleigh scatter:** The dispersion of electromagnetic radiation by particles much smaller than the wavelength of the radiation. The amount of scatter varies inversely as the fourth power of the wavelength, resulting in short wavelengths being scattered far more than longer wavelengths. (ANSI/IES LS-1-20)
- **Receptacle: ANSI C136.41-2013**: Defines the mechanical and electrical interface between an outdoor LED luminaire and a photocell, typically mounted on top of the luminaire. The dimensions of the receptacle are roughly 1.5” high x 2.5” diameter.
    - **NEMA 5-pin:** The 5-position receptacle has three line-voltage power contacts plus two dimming/signal contacts.

- **NEMA 7-pin:** The 7-position receptacle has three line-voltage power contacts plus four dimming/signal contacts. The 7-pin configuration supports field upgrades of the control capabilities of LED luminaires by adding or changing wirelessly networked controllers with sensing and communication abilities.

- **Receptacle: ANSI C136.58-2019 (Zhaga Book 18):** Defines the mechanical and electrical interface between an outdoor LED luminaire and modules for sensing and communication. The data interface is defined by the digital D4i/ANSI C137.4 standard. The specification supports field upgrades of the control capabilities of LED fixtures, by adding or changing 24V modules that provide sensing and communication abilities. The dimensions are roughly 1.1" high x 1.5" diameter.

- **Shield**: Shields are used to minimize light trespass onto adjacent areas. A shield is an internal or external opaque structure that obstructs the backward, forward, or side light distribution in a specific solid angle produced by the shield angle and azimuth. A house-side-shield (HSS) prevents some amount of high angle light from spilling backward behind the luminaire. A front-side-shield (FSS) prevents some amount of high angle light from being emitted towards the street-side. A cul-de-sac-shield (CSS) prevents some amount of high angle light from spilling backwards and sideways.

- **Shield type subgroup:** LUNA qualified outdoor lighting PUDs may include a variety of shield types, such as house-side shields (HSS), cul-de-sac shields (CSS), or front-side shields (FSS), as long as the minimum LUNA efficacy requirements are met. Shield types typically reduce luminaire efficacy, so they may be eligible for an efficacy allowance based on distribution performance. Shield type subgroups cannot be combined. A HSS subgroup, for example, can only contain products with house-side shields, not cul-de-sac shields or front-side shields.

- **Sky glow**: The brightening of the night sky that results from the scattering and reflection of light from the constituents of the atmosphere (gaseous molecules and aerosols), in the direction of the observer. It has two components: natural sky glow and artificial sky glow.

Relationship between DLC SSL V5.1 Technical Requirements and LUNA Technical Requirements

To attain DLC LUNA qualification, products must meet the SSL V5.1 Technical Requirements as a baseline, in addition to the LUNA Technical Requirements outlined in this document. For eligible products utilizing optical shielding to meet the LUNA Technical Requirements, the LUNA requirements provide efficacy allowances to the baseline SSL V5.1 efficacy threshold. In other words, LUNA creates allowances for efficacy where efficacy is compromised due to enhanced dark sky attributes, such as shielding used to minimize light trespass or uplight.

The complete SSL V5.1 Technical Requirements can be viewed on the DLC's website, which apply to indoor and outdoor luminaires, replacement lamps, and retrofit kits. The requirements for outdoor luminaires are summarized for the reader's convenience in the following section, *Overview of SSL Baseline Requirements and Proposed LUNA Requirements*. Please note that the SSL baseline

requirements described in the "Overview of SSL V5.1 Requirements for Outdoor Luminaires" column of **Table 3** have already been adopted and are not subject to modification at this time.

The "Overview of Proposed Draft 2 LUNA Requirements" column in **Table 3** describes additional requirements that a product must meet to attain LUNA qualification. The LUNA Technical Requirements have not yet been adopted and are subject to review and comment. This is the second draft following a public comment period ending on May 21, 2021.

Overview of SSL Baseline Requirements and Proposed LUNA Requirements

Table 3 summarizes the existing SSL V5.1 Technical Requirements and requirements proposed in LUNA Draft 2 for relevant outdoor Primary Use Designations.

Table 3: Overview of existing DLC SSL V5.1 Technical Requirements and Proposed LUNA Requirements

Topic	Overview of SSL V5.1 Requirements for Outdoor Luminaires	Overview of proposed Draft 2 LUNA Requirements, which are in addition to SSL V5.1

Light Output and Efficacy	• Minimum light output by General Application and PUD
	• Minimum efficacy:
	  ○ Standard: 105 lm/W
	  ○ Premium: 120 lm/W
	• Efficacy allowances are available for luminaires with low CCT (≤ 2700K) and/or high color rendition
		• Efficacy allowances are available for shielded luminaires and bollards

Light Distribution	• Zonal lumen distribution requirements by PUD • BUG ratings reported	• Required BUG Ratings per **Table 5** • Shield option or accessory is required to be available • Maximum allowable tilt of +/- 10 degrees • Images of spatial intensity distribution shown on QPL

Topic	Overview of SSL V5.1 Requirements for Outdoor Luminaires	Overview of proposed Draft 2 LUNA Requirements, which are in addition to SSL V5.1

Spectral Quality	**Color Rendition:**
	• Option 1: ANSI/IES TM-30-18:
	  ○ IES $R_f \geq 70$
	  ○ IES $R_g \geq 89$
	  ○ $-18\% \leq$ IES $R_{cs,h1} \leq +23\%$
	• Option 2: CIE 13.3-1995:
	  ○ $R_a \geq 70$
	  ○ Report R_9
	Correlated Color Temperature (CCT):
	• 2200K – 6500K
	Color Maintenance:
	• Maximum chromaticity shift ($\Delta u'v' \leq 0.007$)
		• Correlated Color Temperature (CCT): 2200K - 3000K
		• Images and data of spectral power distribution shown on QPL

Controllability	• Continuous or stepped -dimming required • Integral control sensors and capabilities reported • Communication protocols reported	• Continuous dimming capability to ≤20% of max output power required • Reporting of the dimming standard protocol required • Additional types of integral control capabilities are available for reporting • Additional communication standard protocols are available for reporting
Lumen Maintenance	• Standard: $L_{70} \geq 50{,}000$ hours • Premium: $L_{90} \geq 36{,}000$ hours	• Same as SSL V5.1
Electrical Performance	• Minimum Power Factor (PF): ≥ 0.90 • Maximum Total Harmonic Distortion (THD): ≤ 20%	• Same as SSL V5.1
Warranty	• Minimum warranty: 5 years	• Same as SSL V5.1

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LUNA Version 1 Technical Requirements

These Technical Requirements have not yet been adopted and are subject to review and modification.

Scope of Technical Requirements

Version 1 of the LUNA Technical Requirements establishes pathways for DLC LUNA qualification for luminaires that minimize light pollution, minimize lighting energy use, and provide appropriate visibility for people. Version 1 addresses metrics for light distribution by establishing requirements and reporting standards for distribution; spectral quality by limiting eligible CCTs; and controllability by setting required dimming thresholds using common industry standards - all of which are intended to mitigate light trespass and sky glow.

Some aspects of outdoor lighting are beyond the scope of Version 1 (though may be considered in future revisions). Research and standards for outdoor lighting continue to evolve, and while various effects of outdoor lighting on humans and on other species are the topics of ongoing research, metrics are still under development. As more predictive metrics become standardized that address issues such as discomfort glare, sky glow, and the interactions of spectral components with various species at various times of the night and year, these metrics may be incorporated into future revisions of the LUNA policy.

LUNA Light Distribution Requirements

Feedback received and key changes from Draft 1

The DLC received 100 comments on the Draft 1 LUNA Light Distribution Requirements during the first comment period. After careful assessment of stakeholder feedback, modifications were made within Draft 2 as described in this section. The bullets below describe the general feedback received and the sub-bullets describe how the DLC incorporated these changes into Draft 2:

- *Submitting images of the intensity distribution increases submitter burden.*
    - The DLC heard from manufacturers that submitting additional images of the intensity distribution increases their application burden and duplicates information already available on their websites or readily calculated form photometric data. To address this concern, the DLC will create the images of the intensity distribution internally using submitted photometric test data. These images will be shown on the QPL.
- *Parking Garage PUD should not be eligible for LUNA.*
    - We heard from many stakeholders that parking garage luminaires should illuminate the ceiling deck to create a better environment, and the structure itself prevents high angle light from reaching the sky dome. To address this concern, the DLC has removed this PUD type from LUNA classification eligibility. Parking garage luminaires are still eligible under SSL Technical Requirements V5.1.

- *Outdoor Non-Cutoff and Semi-Cutoff Wall-Mounted Area Luminaire PUDs should not be eligible for LUNA.*
    - The DLC heard from some stakeholders that allowing this PUD into LUNA appears to promote irresponsible lighting practice, as these products may increase uplight and glare relative to the full-cutoff wall luminaire PUD. To address this concern, the DLC is removing this PUD from being eligible for LUNA. This PUD is still eligible for SSL V5.1.
- *The maximum tilt angle of +/- 5 degrees is too small.*
    - The DLC heard from many stakeholders that the proposed title angle for roadway, decorative and area luminaires in Draft 1 was too small. Many stakeholders recommended a maximum tilt of +/- 10 degrees, while some others recommended tilt angles of 45 degrees for roadway lighting. To address this concern, the DLC is increasing the maximum allowable tilt to +/- 10 degrees.
- *Shields should not be required for every area or roadway luminaire.*
    - The DLC heard from many stakeholders that shields are not needed for every pole or arm mounted area, decorative or roadway luminaire, and that when available, shields are often available as an accessory for these luminaire types, not only as a catalog option. The DLC is continuing to require at least one shielding component available for these PUDs, but the shields can be available as an accessory rather than an option. In addition, an image of the shield is no longer required to be shown on the specification sheet or supplemental documentation.
- *Additional testing for shielded luminaires needs to be clarified.*
    - The DLC heard from stakeholders that testing clarifications are needed for products pursuing the voluntary shielding efficacy allowances. Draft 2 clarifies that LM-79/color testing would be required for the worst-case-efficacy shielded product that meets the allowance requirement, and LM-79/distribution testing is needed for the product with the lowest house-side lumen reduction as a function of the shield.

Rationale

Uplight emitted directly from luminaires is unused light, wasting energy and increasing sky glow[1]. In some applications, environmental features such as buildings, trees, canopies, and other surfaces prevent uplight from luminaires and other reflective surfaces from reaching the atmosphere and causing sky glow. However, these features are not present in all applications and no consensus performance model exists that takes surface reflection and obstruction into account. As a result, the LUNA Technical Requirements use prescriptive Uplight (U) Rating thresholds from BUG Ratings (as defined by Annex A in the ANSI/IES TM-15-20 Luminaire Classification System for Outdoor Luminaires) to set maximum limits on uplight emitted directly (light ≥ 90 degrees) from listed luminaires. PUDs that are typically installed under overhead surfaces, such as fuel pump canopy lighting, are allowed a higher threshold U Rating value, under the assumption that the overhead surface will stop much of the uplight from reaching the sky dome.

[1] https://www.energy.gov/sites/prod/files/2017/05/f34/2017_led-impact-sky-glow.pdf

BUG ratings have been adopted and are referenced by many national, state and/or local ordinances, regulations, and policies. They are also required by both primary and secondary references such as LEED v4.1, LEED for Cities and Communities, and the WELL Community Standard. BUG rating data in the *Reported Photometric Performance* section of the DLC SSL QPL will support compliance with these regulations.

Luminaires with auxiliary shielding may improve the quality of the light distribution, as light is only delivered where it is intended, rather than potentially causing light trespass on neighboring locations. Shields may also be used to address glare complaints proactively or retroactively. Manufacturers may offer a variety of shielding options such as house-side shields, cul-de-sac shields, front-side shields, and glare shields. The DLC acknowledges that luminaire efficacy will be reduced with a shield mounted in the field and is introducing a LUNA efficacy allowance to encourage well-shielded products to be listed on the QPL.

Draft LUNA Requirements for Light Distribution

The following section outlines the proposed LUNA requirements for light distribution. **Table 4** includes columns for the metric or application and its associated requirements. The "QPL Listing" column describes the information that appears as publicly available on the Qualified Products List, if applicable. The "Method of Evaluation" column describes how the products will be evaluated for qualification, whether by compliance with industry standards, manufacturer claims, or other DLC verification methodology.

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Metric / Application	LUNA V1 Draft Requirements	QPL Listing	Method of Measurement/ Evaluation
Uplight Rating (from the IES BUG system) †	Products shall have a U-Rating of 0, 1 or 2, depending on Primary Use Designation indicated in **Table 5**. ANSI/IES LM-63 .ies files (and optionally ANSI/IES TM-33-18 .xml documents‡) containing luminous intensity distribution data must be submitted for a representative product for each unique distribution pattern included in the application.	BUG ratings for parent products will be generated by the DLC using tested photometric data and listed under the Tested Data section. BUG ratings for child products are reported by the applicants and listed under the Reported Data section. The DLC will create a .jpg image for the parent or single product to be shown on the QPL, based on the submitted .ies file‡.	ANSI/IES LM-79 per the *Additional Reporting Guidelines.* BUG ratings generated per ANSI/IES TM-15-20 Annex A using luminaire photometric data.
Aiming	Products shall only include mounting options that will not allow tilt angles beyond +/- 10 degrees, in order to align the luminaire parallel with the roadway surface (see **Figure 1**).	Model number will include allowed mounting options. Products with mounting accessories are ineligible for LUNA.	Specification sheet or installation instructions shall include images of mounting options with allowable tilt angles or fixed mounting options clearly documented.
Shielding	Shielding as an available accessory or option shall be included on specification sheet or supplemental documentation (e.g. house side shields (HSS), cul-de-sac shields (CSS), front-side shields (FSS), or glare shields) for pole/arm-mounted area/roadway/ decorative PUDs (Primary Use letters A and B), and specialty hazardous area lighting and specialty hazardous pole/arm-mounted area and roadway PUDs.	Products without shielding will be listed on the QPL per the LUNA requirements. For those who voluntarily choose to list their shielded products, within each given shielding subgroup, shielded products with the lowest efficacy will be listed as worst-case efficacy parent products on the QPL. Shielded products with the highest house-side lumens will be listed as the worst-case distribution parent products on the QPL. Other eligible members of the given shielded subgroup will be listed as child products.	Specification sheet or supplemental documentation review to determine that at least one shielding accessory or option is available.

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† As in V5.1, performance-affecting mounting structures (e.g. post-top yokes or brackets) must be included in photometric testing for Outdoor Pole/Arm-Mounted Area and Roadway Luminaires (Primary Use letter A), Outdoor Pole/Arm-Mounted Decorative Luminaires (Primary Use letter B) and Specialty Hazardous Outdoor Pole/Arm-Mounted Area and Roadway Luminaires.

‡.ies files may be submitted alone without also submitting TM-33 .xml documents up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision. If .xml documents are submitted, .ies files must also be submitted so that Photometric Toolbox can be used by DLC reviewers for evaluation. See the Provisional Testing and Reporting section for more information.

Table 5: PUDs eligible for LUNA qualification and respective U Rating thresholds

Primary Use Letter	Primary Use Designations Eligible for LUNA Qualification	Maximum U Rating Threshold
A	Outdoor Pole/Arm-Mounted Area and Roadway Luminaires	1
B	Outdoor Pole/Arm-Mounted Decorative Luminaires	2
C	Outdoor Full-Cutoff Wall-Mounted Area Luminaires	1
E	Bollards	1
G	Fuel Pump Canopy Luminaires	2
n/a	Specialty: Hazardous Area Lighting	1
	Specialty: Hazardous Outdoor Pole/Arm-Mounted Area and Roadway Luminaires	1
	Specialty: Hazardous Wall Mounted Luminaire	2
	Specialty: Canopy Lighting	2
	Specialty: Directional Fuel Pump Canopy Luminaires	2
	Specialty: Transportation	2

The lighting distribution test reports required to qualify under the LUNA qualification are described as follows:

- A full LM-79 distribution report in PDF format per the Additional Reporting Guidelines for the products that have the highest total lumen output for each optical variation within the family at the highest qualifying CCT (e.g., 3000K), tested at the maximum (non-dimmed) light output.
- An .ies file, and optionally, a TM-33-18 .xml document, both based on the LM-79 test data, must be submitted along with the PDF distribution report.
- A product image including performance affecting mounting structures must be included in the PDF distribution report.
- For tested products in a family grouping application, threshold U Ratings from the BUG Ratings will be verified using the .ies files associated with the full LM-79 distribution test report.
- For all child products in a family grouping application where LM-79- distribution reports are not required, reported data, including BUG ratings, shall be reported in the reported values on the application form.
- DLC reviewers will analyze the submitted .ies files using Photometric Toolbox (Lighting Analysts, Inc., version 2.7 or newer) to verify BUG Ratings and house-side or street-side lumens (for products pursuing shielding efficacy allowances) using the submitted tested photometric files.

DLC reviewers will evaluate drawings and text information on the submitted specification sheets and installation instructions to verify that the qualified mounting bracket does not allow a tilt angle greater

than 10 degrees. The mounting bracket and related maximum tilt angle must be graphically shown on either the specification sheet or installation instructions (see **Figure 1**).

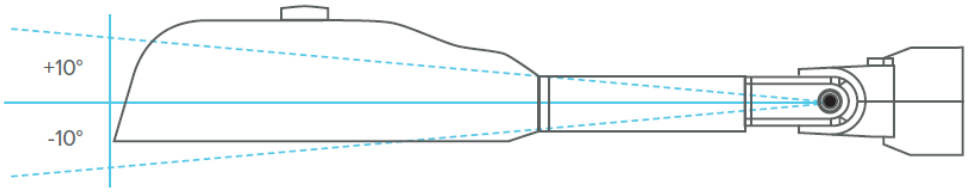

Figure 1: *Acceptable mounting bracket tilt angle for LUNA qualification.*

To attain LUNA qualification, listed pole/arm-mounted area/roadway/decorative PUD products shall offer at least one specifiable shielding option or accessory on the product specification sheet or supplemental documentation. The shields may be external to the luminaire, or internal to the glass or optic. DLC reviewers will evaluate submitted documentation to ensure that a shield option or accessory is available.

Interactions with other DLC policies

Field-adjustable light distribution (FALD) products are not eligible for LUNA qualification. Field-adjustable light output (FALO) products are eligible for LUNA qualification. Please note that this may lead to the need to separate models that were otherwise able to be combined on the SSL QPL, to clearly delineate those qualified for LUNA and those that are not.

Key Questions

1. Is performance information for shielded products useful? Is there any reason the DLC should not offer efficacy allowances to support voluntary listing of LUNA eligible products with shields?
2. The DLC is proposing to require distribution reports submitted as PDF files for LUNA with a requirement that a product image including performance affecting mounting structures must be included in the PDF distribution report. Is there any reason why this requirement can't be met?
3. The DLC is proposing a maximum U Rating of 2 for Specialty: Hazardous Wall Mounted Luminaire PUDs. Can the U rating for this PUD be reduce to maximum of U1, or is there specific value to more uplight for this PUD with regards for safety and security?

LUNA Spectral Quality Requirements

Feedback received and key changes from Draft 1

The DLC received 55 comments on the Draft 1 LUNA Spectral Quality Requirements during the first comment period. After careful consideration of both stakeholder feedback and taking into account implementation considerations, modifications were made within Draft 2 as described in this section. The bullets below describe general themes of the feedback received, and sub-bullets describe how the DLC incorporated those changes into Draft 2:

- *The DLC should not consider tunable products that can operate outside of the LUNA eligible CCT range.*
    - Several stakeholders support including tunable products with functionality outside the LUNA eligible CCT range when software/hardware can effectively limit tunable range. However, the stakeholder majority does not support products that can tune outside of the eligible CCT range as proposed in Draft 1, as this allows for "misuse" and/or "gaming the system". To address these concerns, the DLC is maintaining the Draft 1 proposal that tunable and static products are eligible if they only operate within the eligible range.
- *CCT is only weakly correlated to impacts of light at night and graphical representations of spectral data can be misleading to general and advanced users when attempting to infer specific resulting impacts.*
    - Supporting the LUNA spectral quality rationale below, the DLC heard from most stakeholders that sky glow and light pollution, along with many other considerations, are only weakly correlated to the impacts of light at night. Additionally, the DLC heard that static images of a product's SPD can be misleading for general or even expert users of the QPL when attempting to infer specific impacts resulting from the luminaire's spectra. To mitigate misinterpretations, the DLC proposes to report absolute spectral data in addition to a static .jpg file of the spectra on the QPL based on submitted spectral data.
    - Additionally, the DLC heard from manufacturers that submitting additional images of the spectral distribution increases their application burden and duplicates information already available on their websites or readily calculated. To address this concern, the DLC will create the images of the spectral distribution internally using submitted photometric test data.
    - Please note, the DLC is looking for specific input on formatting requirements for both the spectral data and image reporting requirements, e.g. 1 nm increments between 380-780 nm (data) and/or 1000 x 1000-pixel resolution (image).

Rationale

The DLC is proposing spectral quality requirements to mitigate negative impacts of outdoor LED lighting at night. The draft requirements align with industry standards recommended for mitigating sky glow (e.g. ANSI/IES LP-2-20 Lighting Practice: Designing Quality Lighting for People in Outdoor Environments and ANSI/IES LP-11-20 Lighting Practice: Environmental Considerations for Outdoor Lighting) while

facilitating visibility and energy efficiency for continued acceptance of and persistent energy savings achieved through LED lighting at night.

Since sky glow (and more specifically the Rayleigh scatter causing sky glow) is wavelength dependent, the Department of Energy (DOE) found CCT to be a poor predictor of sky glow. Research and solutions for considering spectral impacts on sky glow are emerging, but there is no industry standard consensus-based metric to replace CCT in place to date. In the meantime, industry best practices limit the maximum CCTs in outdoor environments to reduce short-wavelength emissions. ANSI/IES LP-11-20 recommends maximum CCTs of 3000 Kelvin (i.e. 3000 K) for area lighting in commercial zones, and CCTs lower than 2200 K[4] for area lighting in sensitive environments.

Draft LUNA Requirements for Spectral Quality

The draft spectral quality requirements for all LUNA products are shown in **Table 6**. The "QPL Listing" column describes the information that appears as publicly available on the Qualified Products List, if applicable. The "Method of Evaluation" column describes how the products will be evaluated for qualification, whether by compliance with industry standards, manufacturer documentation, or other DLC verification methodology.

Table 6: Draft LUNA Spectral Quality Requirements

Metric and/or Application	LUNA V1 Draft Requirements	QPL Listing	Method of Measurement/ Evaluation
Chromaticity (CCT & D_{uv})	Products shall exhibit chromaticity consistent with at least one of the basic, flexible, or extended, nominal 7-step quadrangle CCTs from 2200 K – 3000 K. Products shall submit an ANSI/IES TM-33-18 .xml document or ANSI/IES TM-27-20 .spdx file* containing spectral power distribution data.	SPD data and image**, CCT and D_{uv} for parent products listed as Tested Data. Nominal CCT for child products listed as Reported Data.	ANSI/IES LM-79 (per *Additional Reporting Guidelines*) ANSI C78.377-2017

*.spdx files (ANSI/IES TM-27) are accepted up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision.
**The DLC will create a .jpg image for parent products to be shown on the QPL based on the submitted ANSI/IES TM-33-18 .xml document or .spdx file.

[4] No ANSI (or other) standards define CCT ranges extending beyond what is considered 'white' lighting per ANSI C78.377-2017. As such, the DLC is proposing that non-standardized chromaticities are ineligible for listing under LUNA V1.

In addition to test report and implementation requirements applicable to DLC Standard and Premium classifications, this section describes the test reports required to meet LUNA spectral quality requirements.

- If not submitting in a V5.1 SSL application, LUNA product families are required to test and report the following:
    - For product families that offer **one color rendition option and one or more CCT option(s)**:
        - A full LM-79/color report, per the Additional Reporting Requirements, shall be provided at the lowest and highest CCT options offered.
    - For product families that offer **one or more color rendition option(s) and one CCT option**:
        - A full LM-79/color report, per the Additional Reporting Requirements, shall be provided at the minimum color rendition option for the CCT option offered.
    - For product families that offer **one or more color rendition option(s) and one or more CCT option(s)**:
        - A full LM-79/color report, per the Additional Reporting Requirements, shall be provided for the lowest and highest CCT options offered, at the minimum color rendition option.
    - All LM-79/color tests of the highest CCT option offered shall be conducted at the highest total lumen output for at least one optical variation within the family when operating at the maximum (non-dimmed) light output and the .xml document based on the LM-79 test data shall include both spectral and spatial distribution data per the Additional Reporting Requirements.
        - For the product with the highest CCT (at highest lumen output), the TM-33 .xml document shall include both the emitter spectral data and the emitter luminous intensity data for a single tested product.
        - For the spectral parent with the lowest CCT (at highest lumen output), the TM-33 .xml document may include only the emitter spectral data without the emitter luminous data for a single tested product.
        - .spdx files (ANSI/IES TM-27) are accepted up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision.

Interactions with other DLC policies

For color-tunable (white-tunable and warm-dimming) products, additional clarifications to meeting the proposed LUNA spectral quality requirements are provided below.

- White-tunable and warm-dimming products are eligible for LUNA but shall not be tunable to chromaticities outside the proposed LUNA chromaticity requirements (i.e., color-tunable products are eligible for LUNA, so long as the product(s) tune between 2200-3000 K).

Key Questions

1. The DLC has proposed that the maximum and minimum CCT options from LUNA eligible families undergo LM-79 testing. These products will be required to provide SPD data (e.g. .spdx files or .xml documents) which will be reported on the QPL along with a static SPD image generated from the spectral data provided. The DLC is looking for input on specific QPL reporting format and resolution requirements. Specifically, what file format(s) are most useful (e.g. .spdx , .csv, .xlsx files)? What wavelength increment should be reported on the QPL for end users (e.g. 1nm increments, 5nm increments, 20 nm increments)? What proposed image format and resolution is sufficient (e.g. 1000 x 1000 pixels)?

2. The DLC heard that static SPD images can be misleading for even the most expert QPL users and that absolute data is much more informative. To mitigate misleading information, the DLC would like to provide supplemental information to drive education and better inform users of what information could or should be assumed from a static SPD image. What supplemental information is most critical to mitigate misleading assumptions made from viewing static SPD images of LUNA qualified products?

LUNA Controllability Requirements

Feedback received and key changes from Draft 1

The DLC received 47 comments on the Draft 1 LUNA Controllability Requirements during the first comment period. After careful assessment of stakeholder feedback, modifications were made within Draft 2 as described in this section. The bullets below describe the general feedback received and the su- bullets describe how the DLC incorporated these changes into Draft 2:

- *Most commenters agreed that required dimming to 20% is appropriate, as the lowest level consistent with reliably low levels of flicker. Some comments requested lower levels of dimming to address the adaptive response and logarithmic response of the human eye. One comment considered 20% too low, as a threat to safety and liability.*
    - The requirement to dim down to 20% or less of maximum output power is maintained. The ability of any products to dim to values less than 20% will be recognized on the QPL.
- *The DLC received a suggestion to add the following dimming protocols to Table 7: ELV/Reverse Phase, Line voltage 2 Wire, Line voltage 3 Wire, Data. A separate comment suggested to check IES TM-23-17 for a list of dimming standards.*
    - The protocols suggested and described briefly in IES TM-23-17, pages 9-11, were not added because the DLC is not aware of commercial lighting standards for these industry practices.
    - An "Other, text" option was added, to recognize non-standard dimming protocols.
- *The DLC received a suggestion to add dimming standards DMX and Forward Phase to Table 7.*
    - These dimming standards were added as DMX512 and NEMA SSL 7A.
- *The DLC received a suggestion to add network communication standards BACnet, LONworks and Modbus to Table 9.*
    - These industry standards were added.
- *Various comments suggested to clarify wording, which was done*.

Rationale

Sky glow and light trespass can be reduced with high end trim, enabling designers to meet design requirements without overlighting. In addition, light pollution can be reduced flexibly throughout the night by dimming down as far as appropriate, as frequently as appropriate. Solutions include luminaires with stand-alone motion sensors and photocells; smart photocells with part-night-dimming and field adjustable high-end trim; and networked lighting controls (NLC) with remote diagnostics, scheduling, dashboards, etc. In many applications, reducing light output can reduce light pollution while saving energy by delivering precisely the illumination that is needed, only when it is needed. Continuous dimming also facilitates compliance with energy code requirements for light level reduction, including recent versions of ASHRAE 90.1, IECC, and California's Title 24.

Draft LUNA Requirements for Controllability

The following section outlines the proposed LUNA requirements for controllability. The "QPL Listing" column describes the information that appears as publicly available on the Qualified Products List. The

"Method of Evaluation" column describes how the products will be evaluated for qualification, whether by compliance with industry standards, manufacturer claims, or other DLC verification methodology.

Note that every LUNA product must identify its dimming standard protocol between driver and sensor/ controller. For instance, if a product family of luminaires is available with optional dimming, where some members of the family can dim and some cannot, only those members of the family that support dimming controls are eligible for LUNA qualification.

Table 7: Draft LUNA Controllability Requirements

Metric	LUNA V1 Draft Requirements	QPL Listing	Acceptable Terms
Dimming Capability	Continuous dimming capability to ≤20% of max output power is required	Minimum dimming level (integer %)	Product specification sheet shall clearly identify continuous dimming capability, to a percentage of maximum output current or power, less than or equal to 20%.
Dimming standard protocol between driver and sensor/ controller	The dimming standard protocol is required.	Dimming standard protocol	Unlike SSL V5.1 products, models qualified under LUNA must indicate specific dimming protocols available. Dimming protocols cannot be wildcarded if product changes are necessary to achieve the dimming functionality. If a driver accepts only analog or only digital dimming control, then each analog or digital standard that is available with the luminaire is identified on the product specification sheet, with the ordering code and specific model number separated out for each dimming standard option. If a single product with a single ordering code can accept multiple dimming protocols, then all protocols will be identified. SSL V5.1 Wired Communication Protocols for LUNA products will be superseded with the following more detailed options: *(continued below)*

Metric	LUNA V1 Draft Requirements	QPL Listing	Acceptable Terms
			• Wired Analog Standard 1. 0-10V IEC 60929 Annex E 2. 0-10V ANSI C137.1-2019 (8-Volt) 3. 0-10V ANSI C137.1-2019 (9-Volt) 4. Forward Phase NEMA SSL 7A-2015 (R2021) • Wired Digital Standard 1. DALI 2. DALI 2 3. D4i 4. DMX512 • Other (text)
Integral Controls	Capability for integral controls is reported.	Integral control capabilities and receptacle(s)*	Product specification sheet shall clearly identify available integral control capabilities and receptacles, if any, with the ordering code option for each.*
Communication standard protocol between luminaires and other devices	Communication standard protocol is reported.	Communication standard protocol(s)	Product specification sheet shall clearly identify available standards selected from **Table 9** below, with the ordering code option for each.

* **Table 8** below shows integral control capabilities beyond those listed in Table 8 of SSL Technical Requirements V5.1, and also a list of integral control receptacles.

Dimming capability

Dimming is required in many energy codes, and the capability to dim down to 20% of maximum output power addresses multiple dark sky challenges. High end trim and part night dimming are broadly applicable; and occupancy-based dimming is applicable in some situations depending on sensor performance related to coverage area, sensitivity, and mounting height.

Dimming standard protocol between driver and sensor/ controller

In order for a luminaire to dim, a sensor or control module communicates the desired dimming level to the driver, using a dimming protocol. This protocol is typically either an analog 0-10V signal, or a digital signal such as DALI, DALI2 or D4i.

Integral controls

Several types of integral control sensors and capabilities are described in the SSL V5.1 Technical Requirements section on Controllability in Table 8 entitled "Integral Control Sensor and Capability Descriptions". In addition, the following types of control capabilities and receptacles are accepted by the LUNA program, as types of "Integral Controls". Note that information about the receptacle type is necessary, but not sufficient, to choose controls appropriate for a particular receptacle on a particular luminaire. For instance, ANSI C136.41 has 19 signal sets and multiple mechanical interconnection configurations; and Zhaga Book 18 has an undefined pin. Also, various functions support various uses and orientations such as receptacles mounted facing downwards, sideways, or upwards.

Table 8: Integral control capabilities and receptacles recognized by LUNA, in addition to those in SSL Technical Requirements V5.1

Topic	Additional types of integral controls	Acceptable terms
Integral control capabilities beyond those listed in SSL V5.1	Part night dim	Part night dimming
	Photocontrol with self-calibrating astronomic time clock	Photosensor with astronomical timer
	Low-end trim for vacancy mode	Low-end trim for unoccupied state
Integral control receptacles for outdoor luminaires	ANSI C136.41-2013 (NEMA 5-pin)	List of acceptable terms to be determined
	ANSI C136.41-2013 (NEMA 7-pin)	
	ANSI C136.58-2019 (Zhaga Book 18)	
	Other	In order to be accepted, text in this field must include a URL referencing the physical dimensions, electrical properties, and functional aspects of the control receptacle.

Communication standard protocol between luminaires and other devices

In order to support the selection of luminaires and control systems, the information in **Table 9** is reported for LUNA qualified products. This information supplements SSL Technical Requirements V5.1 Table 9 entitled "Control Communication Descriptions". Note that it is not only the communication protocol, but the functionality of the system that impacts compatibility of systems.

Table 9: Communication standard protocol between luminaires and other devices (reported capability)

Physical medium	Standard protocol	Acceptable terms or conditions
Wireless	Bluetooth Mesh	
	• BLE MDP v2	Bluetooth SIG mesh version 2, BLE SIG mesh v2
	• BLE SIG Mesh v1.x	Bluetooth SIG mesh version 1, BLE SIG mesh v1
	• BLE Proprietary	Bluetooth mesh, BLE mesh
	Cellular	
	• 4G	4G, IMT-2000, LTE Advanced, IEEE 802.16m
	• 5G	5G, 3GPP 5G NR, IMT-2020
	EnOcean	EnOcean, Enocean, enocean, listing at enocean-alliance.org/products
	WiFi	
	Zigbee	
	Zigbee 3.0	
	Zigbee Proprietary	
	Other (describe)	
Wired	DALI	
	DALI2	
	DMX512	
	BACnet	
	LONworks	
	Modbus	
	Other (describe)	

Key Questions

1. To support DLC reviewers of product applications, the DLC will compile a glossary of words and phrases that are equivalent to the words in the middle column of Tables 8 and 9, based on the various terms that industry partners use on their cut sheets. For instance, in the top row of Table 8, another name for high-end trim would be task tuning. For the "Acceptable Terms" column in Tables 8 and 9, what specific terms and phrases should be accepted on the product specification sheet?
2. Should any dimming standards be added to Table 7? If so, please provide the official name of each commercial lighting dimming standard in question.
3. Should the list of dimming protocols in Table 7 include an "Other (text)" option, to accept proprietary protocols? Or should the listed dimming standards be the only acceptable options?
4. Should any standards be added to or omitted from Table 8?

LUNA Allowances and Tolerances

Efficacy allowances for bollard PUDs

Bollards that meet all LUNA requirements for distribution, spectrum, and controllability are provided with a 25% efficacy allowance. This allowance is cumulative to other cumulative spectral quality allowances provided in SSL V5.1.

There are no allowances for light output. All PUDs seeking LUNA qualification must meet the minimum light output requirement listed in the SSL V5.1 Technical Requirements.

Efficacy allowance for shielded luminaires

Auxiliary shielding may increase the quality of the light distribution of a luminaire, as light is only delivered where it is intended and does not cause light trespass on neighboring locations. However, the application of shields often results in lower luminaire efficacies, and in many cases, shielded products cannot meet DLC's minimum efficacy requirements. Based on DLC outreach to lighting designers, many have indicated that they use shielded photometry when available. Although manufacturers have to demonstrate that at least one shield option or accessory is available for LUNA qualification, listing additional specific LUNA-qualified products with shields is voluntary. Manufacturers that choose to list LUNA-qualified products with shields will have to test their products with shields as described below.

- Shields that are offered as options will have the shield indicated in the luminaire catalog number and will be shown on the QPL as such.
- Shields that are offered as accessories will have the accessory listed in parentheses at the luminaire catalog number (e.g., "ABC-10W-30K80CRI (with accessory HSS-Black)", where HSS-Black is the nomenclature/ordering code for this accessory).
    - QPL performance and testing required on products with accessories included with the model number in the application will be treated as though the accessory is an option within the model number (i.e. performance will reflect product performance with accessory attached, worst-case testing will include products with accessory attached, etc.).

If a manufacturer offers more than one configuration of a specific shield type (HSS, CSS, and FSS), the variety of configurations under each shield type is treated as a shield type subgroup within the product family (e.g. an HSS subgroup could include internal and external HSS, or an HSS subgroup could include a Type II HSS with a 30-degree shielding angle[5] and a Type II HSS shield with a 45-degree shielding angle). Each shield configuration is listed as a separate reported family member, with the effect on the distribution and light output of the luminaire documented. If products are available with multiple shield colors, the shield color and/or finish must be specified in the model number and cannot be listed as a wildcard option in the listing, because lighter color shields will potentially reflect more light to the sky

[5] Shielding angle is defined in ANSI/IES LS-1 -20 as "the angle between a horizontal line through the light center and the line of sight at which the bare source first becomes visible."

dome and not meet the required U Rating threshold for that PUD. An example of a hypothetical shield subgroup is shown in **Table 10** below.

In all cases, the testing proposed to achieve the specified efficacy allowance is in addition to other testing specified in these technical requirements and all other V5.1 testing. Shielded products must meet all other SSL V5.1 and LUNA requirements, except ZLD, and are offered efficacy allowances as long as specific reductions in relevant zonal lumens are achieved. For example, if a family includes model numbers with shielding accessories or options, of which some meet the efficacy requirement with an allowance and some do not, testing would be required for 1) the worst-case-efficacy shielded product that meets the allowance requirement, and 2) for the product with the lowest house-side lumen reduction as a function of the shield. Shielded products that have efficacies better than the worst-case shielded products, or the lowest house-side lumen reduction, can be child products. Submitters must supply the reported performance for their shielded and unshielded products, as specified in Table 5. The allowance would apply to the specific subgroup of products using the given shield (e.g. HSS or CSS). Shield types cannot be combined to create a larger subgroup. In other words, cul-de-sac shields and house-side shields cannot be combined to create one subgroup.

Table 10 provides an example of a luminaire family with various HSS and FSS options. The worst-case efficacy parent in each subgroup (HSS or FSS) is the product that results in the lowest efficacy, assuming that all HSS or FSS products in the subgroup meet the requirements in Table 10 (reduce the house-side lumens by at least 50% compared to the unshielded equivalent product, and all FSS products reduce the street-side lumens by at least 30% compared to the unshielded equivalent product). The worst-case distribution parent in each subgroup is the product that reduces the house-side or street-side lumens the least.

Table 10: Example of hypothetical shielded products and identified worst-case efficacy and distribution parents for one luminaire family with two shield type subgroups (HSS and FSS)

Row #	Family Name	Optic	Luminaire Efficacy w/o shielding (LPW)	House-side *(or street-side)* lumens w/o shield	Shield Type	Shielding Angle	Shield Type Subgroup	Luminaire Efficacy with shield (LPW)	House-side *(or street-side)* lumens with shield	House/ Street side reduction	Test required
1	AXBXC	Type II	125	3000	HSS	30	A	85	1400	53%	LM-79/ color
2	AXBXC	Type II	125	3000	HSS	45	A	88	1200	60%	
3	AXBXC	Type III	125	3500	HSS	30	A	87	1700	51%	LM-79/ distribution
4	AXBXC	Type III	125	3500	HSS	45	A	89	1500	57%	
5	AXBXC	Type II	125	10000	FSS	30	B	88	6500	32%	LM-79/ color
6	AXBXC	Type II	125	10000	FSS	45	B	90	5000	47%	
7	AXBXC	Type III	125	9500	FSS	30	B	89	7000	30%	LM-79/ distribution
8	AXBXC	Type III	125	9500	FSS	45	B	91	6000	40%	

Note: Worst-case-efficacy parent for each Shield Type Subgroup shown in yellow. LM-79 color testing is required for the least efficacious shielded luminaire in Shield Type Subgroup A (HSS), and the least efficacious shielded luminaire in Shield Type Subgroup B (FSS) – Rows 1 and 5. Worst-case distribution parent in each Shield Type subgroup is shown in blue. LM-79 distribution testing is required for the luminaires with the lowest reduction in house or street side lumens.

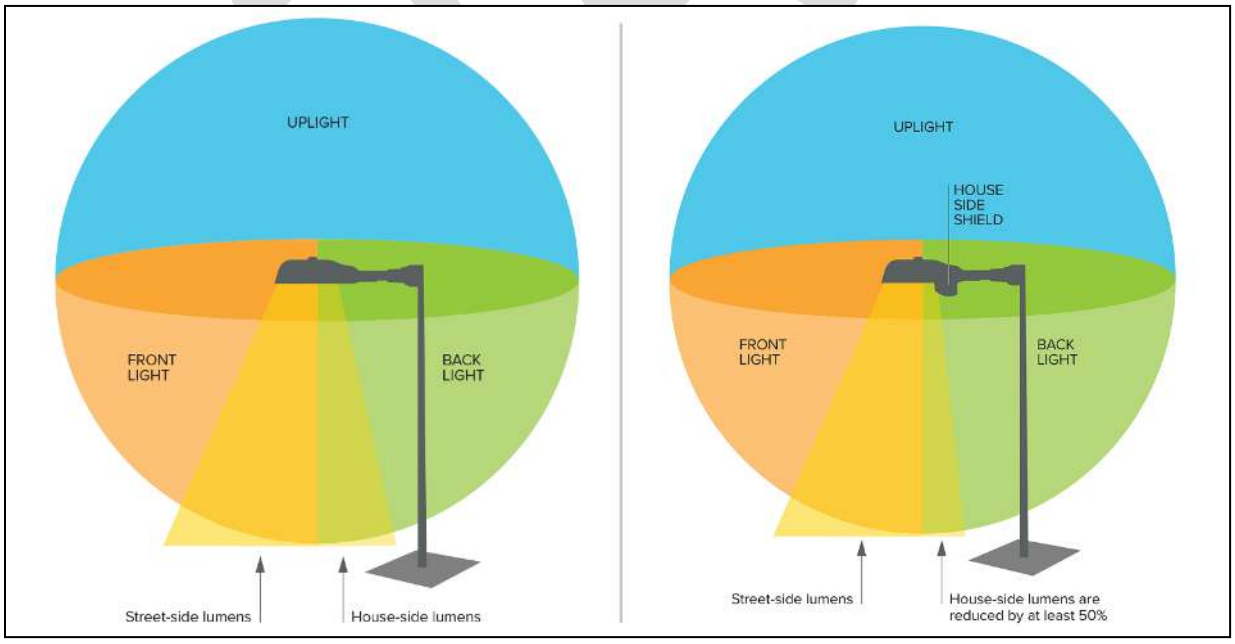

Figure 2: *Example of a hypothetical product with a house-side-shield (HSS) (right image) and without (left image). This hypothetical product with a HSS would be eligible for an efficacy allowance if the house-side lumens are reduced by at least 50% compared to an unshielded equivalent product. Note that other efficacy allowances for other shield types will require different reduction in house side or street side lumens, per* **Table 11**.

To encourage the listing of shielded products, the DLC is providing efficacy allowances for shielded area lighting, roadway lighting, and pole- or arm-mounted decorative lighting with house-side shields or cul-de-sac shields, if the related house-side lumens are reduced by the specified percentage compared to an unshielded product. A similar efficacy allowance is also provided for shielded area lighting, roadway lighting, and pole- or arm-mounted decorative lighting with front-side shields, if the related street-side lumens are reduced by the specified percentage compared to an unshielded product.

Table 11 shows the efficacy allowances for LUNA products with shielding. These allowances are cumulative to other spectral quality allowances provided in SSL V5.1. The maximum allowance for a shielded LUNA-designated product is not limited by the maximum allowance of 10% as stated in the SSL V5.1 requirements. Instead, for LUNA, it may be up to 45%, depending on the shield type.

Table 11: Efficacy allowances specific to LUNA products with shielding

Feature	Primary Use Designations	Performance Metric	Efficacy Allowance
Shielding	• Outdoor Pole/Arm-Mounted Area and Roadway Luminaires • Outdoor Pole/Arm-Mounted Decorative Luminaires • Specialty: Hazardous Area Lighting • Specialty: Hazardous Outdoor Pole/Arm-Mounted Area and Roadway Luminaires	Luminaires with internal or external house-side shields (HSS) are offered an efficacy allowance of 20% if they reduce the house-side lumens by at least 50% compared to an equivalent unshielded product.	-20%
		Luminaires with internal or external cul-de-sac shields (CSS) are offered an efficacy allowance of 35% if they reduce the house-side lumens by at least 70% compared to an equivalent unshielded product.	-35%
		Luminaires with internal or external front-side shields (FSS) are offered an efficacy allowance of 20% if they reduce the street-side lumens by at least 30% compared to an equivalent unshielded product.	-20%

Testing Notes

To determine if the efficacy allowance may be granted for a single product application or a worst-case efficacy parent product, applicants must submit a .ies file of the equivalent unshielded product, with the same optical distribution and nominal light output as the submitted shielded worst-case efficacy parent. To confirm the shielding allowance, the .ies file associated with the unshielded product does not need to use absolute photometry (scaled photometry is acceptable). The submitted specification sheet or supplemental document should clearly show the relationship between the unshielded product and shielded product for reviewer's analysis. The DLC will accept .ies files (ANSI/IES LM-63) up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision.

The LM-79/distribution report for the worst-case distribution parent must be submitted as a PDF file and must include a product image with the shield with sufficient granularity that the shield is clearly visible in the image.

Tolerances

The DLC accepts measurement tolerances to certain metrics listed in the SSL V5.1 Technical Requirements. Please refer to the SSL V5.1 Technical Requirements for acceptable tolerances. There are no higher upper tolerances to the threshold Uplight Ratings given in **Table 4** of this document.

Provisional Testing and Reporting Requirements

The following testing and reporting requirements describe which test methods and reporting versions are acceptable in LUNA Version 1. Manufacturers can initially use any of the following testing and reporting file formats in their LUNA V1 applications up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision. However, manufacturers will eventually need to provide ANSI/IES LM-79-19 reports and ANSI/IES TM-33-18 .xml documents prior to the LUNA Version 1 delist date for their products to maintain listing. The DLC intends to require TM-33-18 .xml documents in the future.

LM-79 testing

LUNA Version 1 will allow either the ANSI/IES LM-79-08 or LM-79-19 test method to be used. See the Additional Reporting Guidelines section for more details on any version requirements.

LM-79 reporting

Distribution: Manufacturers must submit .ies files (ANSI/IES LM-63-08 or LM-63-19) along with the PDF distribution report. The DLC encourages manufacturers to submit ANSI/IES TM-33-18 .xml documents for LUNA Version 1 as well, but it is not required for this version.

Spectral Quality: Manufacturers may submit either ANSI/IES TM-27-20 .spdx files or ANSI/IES TM-33-18 .xml documents for LUNA Version 1.

Additional Reporting Guidelines: ANSI/IES LM-79 Reports and Accompanying Spectral and Spatial Distribution File(s)

SSL products or family groupings shall be tested according to the guidelines in specified ANSI/IES Lighting Measurement (LM) documents. Test reports generated by a test lab that complies with the DLC LM-79 testing requirements will be accepted only if all optical and electrical performance are tested and documented as described below. ANSI/IES LM-79-08 or LM-79-19 reports are required. All tests shall be conducted at the full output or non-dimmed state.

All submitted photometric test reports must comply with the full LM-79/color report or full LM-79/distribution report definitions below. Configurations tested to produce full LM-79/color reports and full LM-79/distribution reports will be listed as parent products on the QPL with the tested performance data based on the QPL listing information in each applicable section. If a full LM-79/color report and full

LM-79/distribution report are provided on the same configuration, the tested performance listed on the QPL will be the worst performing data set.

From a file format perspective, the DLC encourages adoption and use of ANSI/IES TM-33-18 .xml documents instead of .ies and .spdx file formats for the following reasons:

- Combines spectral and spatial data
- Inclusion of many commonly used metrics (e.g. color rendition metrics)
- Allows for calculation of alternative application metrics (e.g. to support metrics beyond lumens)

The DLC realizes that photometric testing and application software does not currently readily support ANSI/IES TM-33-18 export/import and is providing reporting alternatives in LUNA Version 1. Therefore, .ies and .spdx files are accepted up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision.

Test reports that require color performance information (generally expected to be from testing in an integrating sphere, though gonio-spectroradiometer testing is also acceptable) do not require distribution performance information unless specified. These color-specific test reports are generally referred to within this document as “full LM-79/color reports” and shall include, but are not limited to, the following:

- Electrical characteristics (wattage, input voltage, THD and PF)
- Total luminous flux
- Efficacy
- Chromaticity ((x,y) and (u’,v’))
- CCT and D_{uv}
- ANSI/IES TM-30-18 Full Report (per Annex D, Figure D-3)
- CIE 13.3-1995 complete Color Rendering Index Detail
- A TM-33 (ANSI/IES TM-33-18) .xml document meeting the following requirements:
    - Test report number, test lab, issue date, manufacturer, and luminaire catalog number are correctly and pertinently indicated using the keywords [TEST], [TESTLAB], [ISSUEDATE], [MANUFAC], and [LUMCAT], respectively.
    - Emitter spectral data with absolute luminaire-level spectral power distribution data from 380-780 nm in ≤5 nm increments. For the spectral subgrouping parent with the highest CCT and highest lumen output, the TM-33 .xml document shall include both the emitter spectral data and the emitter luminous intensity data for a single tested product.
    - For the products with the lowest CCT and highest lumen output, the TM-33 .xml document may include only the emitter spectral data without the emitter luminous data for a single tested product.
    - TM-33 .xml documents containing spatial and/or spectral data must also be submitted by the end of V5.1 applications are no longer accepted in a future Technical Requirements revision, if not submitted with the original application.

- As described in the Provisional Testing and Reporting Requirements section, .spdx files (ANSI/IES TM-27-20) are accepted in place of TM-33 .xml documents until V5.1 applications are no longer accepted in a future Technical Requirements revision.
    - All required TM-33 elements shall be reported in the TM-27 .spdx files when utilizing this reporting format.
- The product model number shall be present and match in all of the relevant TM-27/TM-33/LM-63 and LM-79 documents.
- All information listed above, except the accompanying TM-33 and/or .spdx document, shall be included in a single LM-79/color test report. Separate ANSI/IES TM-30-18 reports will not be accepted.

Test reports that require distribution performance information (generally expected to be from testing with a goniophotometer) do not require color performance information unless specified. These distribution-specific test reports are generally referred to within this document as “full LM-79 distribution reports” and shall include, but are not limited to, the following:

- Electrical characteristics (wattage and input voltage)
- Luminous intensity distribution (Candela array)
- A photo of the product in the goniophotometer as tested with performance affecting structures must be included in the distribution test PDF report.
- If submitting LM-79-19 reports, stray light removal for the purposes of determining the threshold U Rating must be performed and reported according to LM-75-19 (Section 9.0 including the reporting requirements in section 9.5)
- A TM-33 (ANSI/IES TM-33-18) .xml document meeting the following minimum requirements:
    - Test report number, test lab, issue date, manufacturer, and luminaire catalog number are correctly and pertinently indicated using the keywords [TEST], [TESTLAB], [ISSUEDATE], [MANUFAC], and [LUMCAT], respectively.
    - In the TM-33 .xml document, the Intensity Scaling Element (4.5.13.2.4.1) shall be 'false', meaning that the reported intensity data has not been scaled uniformly with respect to laboratory measurements.
    - In the TM-33 .xml document, the spatial distribution shall be presented as emitter luminous intensity data.
    - If a given parent product or single product has a unique optic and the highest lumen output has been tested to meet both the spectral and distribution requirements, a TM-33 .xml document shall be submitted with both spectral and spatial data within, rather than the submitter providing separate TM-33 .xml documents.
    - The emission areas in the TM-33 .xml document file shall appropriately reflect the luminous opening of the luminaire. In no circumstances shall the emission areas be zero or exceed the luminaire’s physical dimensions, and DLC reviewers will verify the emission areas in the TM-33 .xml document against the luminaire physical dimensions

that are provided either in the specification sheet, LM-79 test report, or as separate application submission materials.

  - The angular resolution for the emitter luminous intensity data in the TM-33 .xml document shall comply with the scanning resolution specified in LM-79 (Section 9.3.3 in LM-79-08 and Section 7.3.3 in LM-79-19) and be fine enough to accurately characterize the product's intensity distribution. For products with a wide-angle, smooth intensity distribution, the luminous intensity distribution data shall be in a resolution of 5 degrees or less in the vertical plane and 22.5 degrees or less in horizontal planes. A smaller vertical angular increment must be used for products whose luminous intensity changes rapidly as a function of angle.
  - Manufacturers submitting TM-33 .xml documents must also submit .ies files so that they can be evaluated using Photometric Toolbox.

- Alternatively, .ies files (ANSI/IES LM-63-19 or ANSI/IES LM-63-02) must also be submitted up until the LUNA Version 1 delist date, which will not be until V5.1 applications are no longer accepted in a future Technical Requirements revision. For manufacturers submitting an LM-63-19 .ies file, products must be tested and reported using absolute photometry methods per IES LM-63-19, not scaled photometry, and must include the File Generation Type Value 1.10000 or 1.11000 per IES LM-63-19 Table 2. For manufacturers submitting an LM-63-02 .ies file, the reporting guidelines in V5.1 must be followed.

Test reports containing only a partial set of LM-79 metrics (for example, an integrating sphere test report without luminous flux reported), will not be accepted for application review purposes. For clarity, even if a test is needed for purposes of verifying chromaticity, it must be a full LM-79/color report as described herein, with all required metrics reported.

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References

Standard # or Document Name	Title and URL
ANSI C136.41-2013	Roadway And Area Lighting Equipment–Dimming Control Between An External Locking Type Photocontrol And Ballast Or Driver https://webstore.ansi.org/Search/Find?in=1&st=c136.41
ANSI C136.58-2019	Roadway And Area Lighting Equipment - Luminaire Four-Pin Extension Module And Receptacle - Physical And Electrical Interchangeability And Testing https://webstore.ansi.org/Search/Find?in=1&st=c136.58
ANSI C137.1-2019	Lighting Systems - 0-10V Dimming Interface For LED Drivers, Fluorescent Ballasts, And Controls https://webstore.ansi.org/Standards/NEMA/ANSIC1372019-2392108
ANSI C137.4-2019	Lighting Systems - Digital Interface With Auxiliary Power https://webstore.ansi.org/Standards/NEMA/ANSIC1372019-2392109
ANSI C78.377-2017	Electric Lamps - Specifications For The Chromaticity Of Solid-State Lighting Products https://webstore.ansi.org/Standards/NEMA/ANSIC783772017
ANSI/ASHRAE/IES 90.1-2019	Energy Standard for Buildings Except Low-Rise Residential Building https://www.ashrae.org/technical-resources/bookstore/standard-90-1
ANSI/IES LM-63-02	Lighting Measurement: APPROVED METHOD: IES STANDARD FILE FORMAT FOR THE ELECTRONIC TRANSFER OF PHOTOMETRIC DATA AND RELATED INFORMATION https://www.lisungroup.com/wp-content/uploads/2020/02/IESNA-LM-63-2-2002-Standard-Free-Download.pdf
ANSI/IES LM-63-19	Lighting Measurement: APPROVED METHOD: IES STANDARD FILE FORMAT FOR THE ELECTRONIC TRANSFER OF PHOTOMETRIC DATA AND RELATED INFORMATION https://store.ies.org/product/lm-63-19-approved-method-ies-standard-file-format-for-the-electronic-transfer-of-photometric-data-and-related-information/
ANSI/IES LM-75-19	Lighting Measurement: APPROVED METHOD: GUIDE TO GONIOMETER MEASUREMENTS AND TYPES, AND PHOTOMETRIC COORDINATE SYSTEMS https://store.ies.org/product/lm-75-19-approved-method-guide-to-goniometer-measurements-and-types-and-photometric-coordinate-systems/
ANSI/IES LM-79-08	Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products https://www.lisungroup.com/wp-content/uploads/2019/07/IES-LM-79-08-2008-Standard-Free-Download.pdf
ANSI/IES LM-79-19	Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products https://store.ies.org/product/lm-79-19-approved-method-optical-and-electrical-measurements-of-solid-state-lighting-products/
ANSI/IES LP-11-20	Lighting Practice: Environmental Considerations for Outdoor Lighting https://store.ies.org/product/lp-11-20-lighting-practice-environmental-considerations-for-outdoor-lighting/
ANSI/IES LP-2-20	Lighting Practice: Designing Quality Lighting for People in Outdoor Environments https://store.ies.org/product/ansi-ies-lp-2-20-lighting-practice-designing-quality-lighting-for-people-in-outdoor-environments/

Standard # or Document Name	Title and URL
ANSI/IES LS-6-20	Lighting Science: Calculation of Light and Its Effects https://store.ies.org/product/ls-6-20-lighting-science-calculation-of-light-and-its-effects/
ANSI/IES TM-15-20 Annex A	Technical Memorandum: Luminaire Classification System for Outdoor Luminaires, Annex A https://store.ies.org/product/tm-15-20-technical-memorandum-luminaire-classification-system-for-outdoor-luminaires/
ANSI/IES TM-23-17	Technical Memorandum: Lighting Control Protocols https://www.stdlink.com/standards/ies-tm-23-17.html
ANSI/IES TM-27-20	Technical Memorandum: IES Standard Format for the Electronic Transfer of Spectral Data https://store.ies.org/product/tm-27-20-technical-memorandum-ies-standard-format-for-the-electronic-transfer-of-spectral-data/
ANSI/IES TM-30-20	IES Method for Evaluating Light Source Color Rendition https://store.ies.org/product/tm-30-20-ies-method-for-evaluating-light-source-color-rendition/
ANSI/IES TM-33-18	Standard Format for the Electronic Transfer of Luminaire Optical Data https://store.ies.org/product/tm-33-18-technical-memoranda-standard-format-for-the-electronic-transfer-of-luminaire-optical-data/
BACnet	BACnet - A Data Communication Protocol for Building Automation and Control Networks http://www.bacnet.org
BLE MDP v1.x	Bluetooth Low Energy Mesh Device Properties, Revisions 1.0, 1.1, 1.2 https://www.bluetooth.com/specifications/specs/
BLE MDP v2	Bluetooth Low Energy Mesh Device Properties, Revision v2 https://www.bluetooth.com/specifications/specs/mesh-device-properties-2/
CA Title 24	California Building Energy Efficiency Standards - Title 24 https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards
CIE 13.3-1995	METHOD OF MEASURING AND SPECIFYING COLOUR RENDERING PROPERTIES OF LIGHT SOURCES http://cie.co.at/publications/method-measuring-and-specifying-colour-rendering-properties-light-sources
D4i ANSI	D4i is the DALI standard for intelligent, IoT-ready luminaires. Aligned with NEMA/ANSI C137.4 Lighting Systems - Digital Interface With Auxiliary Power https://www.dali-alliance.org/d4i/ https://webstore.ansi.org/standards/nema/ansic1372019-2392109?gclid=CjwKCAjwt8uGBhBAEiwAayu_9YQ-kUcuUlAZkR05duKoPcXbMY7wpV5j2wjQZRjg7HU5ythgh4VxURoCSH0QAvD_BwE
DALI	IEC 62386 https://www.dali-alliance.org/
DALI2	Certification program based on parts of IEC 62386 and D4i https://www.dali-alliance.org/

Standard # or Document Name	Title and URL
DLC SSL Technical Requirements V5.1	DLC Solid State Lighting Technical Requirements V5.1 https://www.designlights.org/our-work/solid-state-lighting/technical-requirements/ssl-v5-1
DLC NLC5 Technical Requirements	DLC Networked Lighting Controls Technical Requirements version 5 https://www.designlights.org/our-work/networked-lighting-controls/technical-requirements/nlc5/
DLC Horticultural Technical Requirements	DLC Horticultural Technical Requirements https://www.designlights.org/our-work/horticultural-lighting/technical-requirements
DMX512-A	ANSI E1.11-2008 (R2018) Entertainment Technology-USITT DMX512-A Asynchronous Serial Digital Data Transmission Standard for Controlling Lighting Equipment and Accessories https://tsp.esta.org/tsp/documents/docs/ANSI-ESTA_E1-11_2008R2018.pdf
EnOcean	EnOcean Alliance self-powered wireless communication https://www.enocean-alliance.org/
IEC 60929	IEC 60929:2011+AMD1:2015 CSV Consolidated version. AC and/or DC-supplied electronic control gear for tubular fluorescent lamps - Performance requirements https://webstore.iec.ch/publication/23568
IECC 2018	2018 International Energy Conservation Code (IECC) https://codes.iccsafe.org/content/IECC2018P4
IES/IDA MLO	IES/IDA Model Lighting Ordinance https://store.ies.org/product/ida-ies-mlo-11-model-lighting-ordinance-mlo-with-users-guide/
LonWorks	ISO/IEC 14908 LonWorks local operating network https://www.lonmark.org
Modbus	Modbus https://www.modbus.org
US DoD UFC	Department of Defense Unified Facilities Criteria (DoD UFC) https://www.wbdg.org/ffc/dod/unified-facilities-criteria-ufc
US FEMP	Federal Energy Management Program (FEMP) https://www7.eere.energy.gov/femp/requirements/requirements_filtering/facility_energy_efficiency
US GSA P100	General Services Administration's (GSA) P100 Facilities Standards for the Public Buildings Service https://www.gsa.gov/real-estate/design-construction/engineering-and-architecture/facilities-standards-p100-overview
WiFi	Wi-Fi IEEE 802.11
Zigbee 3.0 Full Stack	IEEE 802.15.4-2011 Zigbee 3.0 Full Stack https://zigbeealliance.org/zigbee_products/?product_type=certified_product

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