Draft policy for stakeholder comment

Technical Requirements for LED-based Horticultural Lighting Version 3.0

DRAFT 1

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Contents

Introduction

Horticultural lighting products using LEDs must comply with the provisions of this document to be eligible for listing on the DLC Solid-State Horticultural Lighting Qualified Products List ("Horticultural QPL", "Hort QPL"). Products eligible for DLC qualification must be complete LED light fixtures or lamps. That is, they must be electromagnetic radiation-generating devices analogous to luminaires (or fixtures) or LED lamps (integrated and non-integrated) as defined by ANSI/IES LS-1-20 sections 6.8.5 and 10.3.1 or 6.8.5.3 and 6.8.5.4, respectively.

Version 3.0 Draft 1 of the Horticultural Technical Requirements proposes new performance thresholds, introduces required reporting of intended use case information and fixture-level controllability attributes, and introduces a surveillance testing policy to support the advancement of energy efficient lighting in controlled environment agriculture.

Definitions

Unless otherwise noted, DLC policy nomenclature directly references the definitions from the American Society of Agricultural and Biological Engineers (ASABE) *ANSI/ASABE S640: Quantities and Units of Electromagnetic Radiation for Plants (Photosynthetic Organisms)*, and, where applicable, the Illuminating Engineering Society (IES) *ANSI/IES RP-45-21, Recommended Practice: Horticultural Lighting and ANSI/IES LS-1-20, Lighting Science: Nomenclature and Definitions for Illuminating Engineering,* with key deviations or interpretations noted. Each mention of the term "LED device" in this document is meant to reference LED packages, modules, or arrays.

Eligibility

Products designed and intended to operate with standard North American nominal AC line voltages (typically 120V-480V) or with DC voltages below 600V are eligible for DLC qualification. The following are further rules for horticultural lighting equipment.

- Ineligible products include:
    - Products that are light engines (analogous to LS-1-20 section 6.8.5.5) or identified as retrofit kits intended to replace the light sources or other structures within an existing fixture.
    - Fixtures and/or lamps that incorporate light sources other than LED, whether as sole-source or as LED-hybrid fixtures.
    - Products that are dynamically configurable, i.e., having no defined configuration or set of configurations and whose form factor may vary in the grow facility, are not eligible as an AC product.
- Manufacturers must list full and complete model numbers that clearly demonstrate all qualified product options offered.

- “Full and complete model numbers” means model numbers that include all performance-affecting and non-performance-affecting variations offered, and that do not omit any option that is available to customers in the market. In general, options that do not affect the performance of the product may be submitted as a single model number, and the multiple options may be denoted by bracketing them in the model number.

  For example, a product that has multiple exterior paint color options or mounting options that do not affect performance may include all color and mounting options in brackets (e.g., "[WH, BLK, SLV, GRY]") within a single model number. Low and high voltage options may be submitted as a single model number (e.g., "ABC 300 [120V-277V, 347V-480V] WH") with the worst-case performance reported. Multiple driver variations may be included in single product applications, as noted above, and listed in a single model number, as long as they perform nominally the same. If the drivers perform nominally differently – that is, they are not presented to customers as having the same performance other than voltage input and result in different ordering codes – then the unique drivers must be listed in separate model numbers. Options that affect the flux output, presence or lack of dimming capabilities, or spectral tuning options may not be bracketed and submitted as a single model number.

- DLC reviewers may check web listings and other marketing materials and reserve the right to request additional information to demonstrate the full and complete model number. A lack of clarity in model numbers will result in delayed application processing; misrepresentation of model numbers discovered outside the application process will generally be considered a violation of the DLC program and trademark rules and may result in delisting.

- Each model number may only represent the fixture/lamp under a single brand. If the fixture/lamp can be sold under multiple brands, model numbers must be listed separately for each brand.

Testing Methods and Requirements

The DLC Technical Requirements for LED-based Horticultural Lighting are as follows. Details explaining each item follow **Table 1**.

Table 1: DLC Horticultural Lighting Technical Requirements

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
Photosynthetic Photon Flux (Φ_p or PPF) ($\mu mol \times s^{-1}$)	n/a	Reported	(ANSI/IES LM-79) 400-700nm range, with 400-500nm, 500-600nm, and 600-700nm bins reported alongside the total
Far-Red Photon Flux ($\Phi_{p,fr}$ or PF_{FR}) ($\mu mol \times s^{-1}$)	n/a	Reported	(ANSI/IES LM-79) 700-800nm range
Photon Flux (PF_{PBAR}) ($\mu mol \times s^{-1}$)	n/a	Reported (Optional)	(ANSI/IES LM-79) 280-800nm range
Spectral Quantum Distribution (SQD) ($\mu mol \times s^{-1} \times nm^{-1}$)	n/a	Reported	(ANSI/IES LM-79) (ANSI/IES TM-33-18) 400-800nm range
Photosynthetic Photon Intensity Distribution (I_P or PPID) ($\mu mol \times s^{-1} \times sr^{-1}$)	n/a	Reported	(ANSI/IES LM-79) (ANSI/IES TM-33-18) 400-700nm range
Photosynthetic Photon Efficacy [1] (K_p or PPE) ($\mu mol \times J^{-1}$)	≥2.30 $\mu mol \times J^{-1}$ [2]	Required/ Threshold	(ANSI/IES LM-79) 400-700nm range

[1] DC-powered fixtures must meet the PPE threshold requirement at their AC de-rated PPE value. See "Special Considerations for DC-Powered Fixtures" for more information on AC de-rating.
[2] Currently, the DLC follows a prescribed timeline regarding revision cycles and planned efficacy increase. The draft PPE listed here follows the prescribed policy.

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
Photon Efficacy (PE_{PBAR}) ($\mu mol \times J^{-1}$)	n/a	Reported (Optional)	(ANSI/IES LM-79) 280-800nm range
Photon Flux Maintenance, Photosynthetic (PFM_P)	Q_{90} ≥36,000 hours	Required/ Threshold	(ANSI/IES LM-80 / IES TM-21 or IES LM-84 / IES TM-28) 400-700nm range, fixture specification sheet, and *In-Situ Temperature Measurement Test* (ISTMT)
Photon Flux Maintenance, Far-Red (PFM_{FR})	Report time to Q_{90}	Reported	(ANSI/IES LM-80 / IES TM-21 or IES LM-84 / IES TM-28) 700-800nm range
Driver Lifetime	≥50,000 hours	Required/ Threshold	Driver specification sheet, fixture specification sheet, and *In-Situ Temperature Measurement Test* (ISTMT)
Fan Lifetime	≥50,000 hours	Required/ Threshold	Fan specification sheet, fixture specification sheet
Warranty	Fixtures: ≥5 years Lamps: ≥3 years	Required/ Threshold	Legal warranty terms & conditions
Power Factor (PF)	≥0.9	Required/ Threshold	Benchtop electrical testing or ANSI/IES LM-79
Total Harmonic Distortion, Current (THDi)	≤20%	Required/ Threshold	Benchtop electrical testing or ANSI/IES LM-79
Safety Certification	Horticultural Lighting designation by OSHA NRTL or SCC-recognized body	Required	ANSI/UL 8800 (ANSI/CAN/UL 8800)

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
Application Information	Report controlled environment(s) and lighting scheme(s)	Reported	Product specification sheet
Controllability	Dimming capability required	Required	Driver and/or product specification sheets
	Report dimming range, dimming and control method designations to the product, control attribute(s), and transmission hardware(s)	Reported	Driver and/or product specification sheets

Output Characteristics

The DLC requires testing and reporting of the following characteristics for the output of horticultural lighting devices.

- **Photosynthetic Photon Flux (Φ_p or PPF), (µmol × s^{-1})**
  This is the total output of the product over the specific range of wavelengths defined by ANSI/ASABE S640 for PPF (400-700nm). This metric is an integrated value for the entire fixture and contains no spectral or directional information.

  The DLC Horticultural QPL reports on both the total and ~100nm-wide "bins" of flux within this range to allow end users to understand the fixture's relative proportions. Test information must provide output in these ranges specifically, in addition to the total 400-700nm output.

- **Far-Red Photon Flux ($\Phi_{p,fr}$ or PF_{FR}), (µmol × s^{-1})**
  This is the output of the product over the "far-red" band defined by ANSI/ASABE S640 (700-800nm). This metric is an integrated value for the entire fixture and contains no spectral or directional information. This metric is reported only and does not have a qualifying threshold.

  The DLC Horticultural QPL reports on the total flux of this 100nm-wide band separately for end users' informational needs.

- **Photon Flux (PF_{PBAR}), (µmol × s^{-1})**
  This is the output of the product over a plant's "photobiologically active radiation" (PBAR) wavelength range (280-800nm). This metric is an integrated value for the entire fixture and contains no spectral or directional information. This metric is optionally reported only and does not have a qualifying threshold.

  The DLC Horticultural QPL reports on the total flux of this PBAR band specifically for end users' informational needs. PF_{PBAR} is intended to convey UV, PAR, and FR radiation, which are often associated with photomorphological effects in plants. PF_{PBAR} is not an ASABE S640 defined term and is not required for DLC qualification, though it can be reported and listed if desired by applicants.

- **Photon Efficacy (PE_{PBAR}), (µmol × J^{-1})**
  This is the output of the product over a plant's "photobiologically active radiation" (PBAR) band (280-800nm) divided by the total electrical input watts to the fixture, including any other ancillary loads (controllers, sensors, cooling fans, etc.) used within the lighting system. This metric is an integrated value for the entire fixture and contains no spectral or directional information. This metric is optionally reported only and does not have a qualifying threshold.

  The DLC Horticultural QPL reports on the total flux of this PBAR band specifically for end users' informational needs. PE_{PBAR} is intended to convey luminaire efficacy in converting electrical energy into UV, PAR, and FR radiation, which are often associated with photomorphological effects in plants. PE_{PBAR} is not an ASABE S640 defined term and is not required for DLC qualification, though it can be reported and listed if desired by applicants.

- **Spectral Quantum Distribution (SQD), (µmol × s^{-1} × nm^{-1})**
  This is the distribution of photon flux per photon wavelength over the photosynthetic and far-red range of wavelengths defined by ANSI/ASABE S640 (400-800nm). The DLC will also accept the distribution of photon flux per photon wavelengths over the PBAR range (280-800nm). When reporting either of the optional PBAR metrics (i.e., PF_{PBAR} and PE_{PBAR}), distribution of photon flux over the PBAR range is required. This distribution is measured and reported as integrated in all directions from the fixture and contains no granular directional information itself. This distribution shall be measured and reported from an appropriately accredited facility.

  An image of this distribution shall be submitted within the application in a .jpg graphical file format, at a size of 300x300 pixels or larger. This image will be accessible to users on the QPL. The DLC intends to utilize the required .xml file per ANSI/IES TM-33- and is planning to release a publicly available tool to generate these images during the Version 2 listing period.

  For additional information, please refer to the TM-33-18 Reporting section.

- **Photosynthetic Photon Intensity Distribution (I_P or PPID), (µmol × s^{-1} × sr^{-1})**
  This is the distribution of photosynthetic photon intensity per unit solid angle leaving the fixture. This distribution is measured and reported as integrated for all wavelengths across the 400-700nm range leaving the fixture and contains no spectral distribution information itself. This distribution must be measured and reported from an appropriately accredited facility.
  An image of this distribution is to be submitted within the application in a .jpg graphical file format, at a size of 300x300 pixels or larger. This image will be accessible to users on the QPL.

The DLC intends to utilize the required .xml file per ANSI/IES TM-33- and is planning release of a publicly available tool to generate these images in the near future, during the Version 2 listing period.

For additional information, please refer to the TM-33-18 Reporting section.

Efficacy

The DLC requires testing and reporting of the following characteristics for the output of horticultural lighting devices.

- **Photosynthetic Photon Efficacy (PPE),**
  This is the output of the fixture over the specific range of wavelengths defined by ANSI/ASABE S640 for PPF (400-700nm), divided by the total electrical input watts to the fixture, including any other ancillary loads (controllers, sensors, cooling fans, etc.) used within the lighting system.

All products shall have a PPE of ≥ 2.30 µmol × J^{-1}. In both submitted applications and under surveillance testing, the DLC allows an absolute tolerance of -5% to this threshold value. The result of this is the DLC's acceptance of any test report showing an efficacy of 2.19 µmol × J^{-1} or higher, and the disqualification of any product, either during submission or surveillance testing, with a test report showing an efficacy less than 2.19 µmol × J^{-1}, at any point in the product's specified operating voltage range. All evaluations and listings of this measurement will be rounded to the nearest hundredth.

If a product contains multiple drivers:

- All driver specification sheets shall be provided.
- For each unique driver used, manufacturers shall provide electrical testing to document which driver variation results in the overall minimum K_p (PPE) or worst-case driver efficiency, as well as which variation results in the overall worst-case power quality (THDi and PF).
    - This testing shall include the input current and wattage; the output voltage, current, and wattage; and the THDi and PF for each driver, at each nominal input voltage.
    - In-house (i.e., non-accredited lab) benchtop electrical testing is sufficient for demonstrating the driver variation that yields the overall minimum K_p (PPE) and minimum power quality at the applicable loading conditions and at the applicable input voltages.
    - From this electrical characterization testing, the product and conditions representing worst-case efficacy shall undergo formal whole-fixture LM-79 testing by an accredited testing lab.
    - For questions about testing requirements for Level 2 applications (formerly Family Grouping applications), please refer to the Level 2 (formerly Family Grouping) Application Requirements for LED-based Horticultural Lighting.
- Drivers that result in explicitly different nominal fixture performance (for example, a driver change which results in different flux output by the product, determined at the DLC's discretion) are not permissible variations within a single model number and are required to submit a Level

2 application for QPL listing. If alternate driver variations result in different input wattage, worst-case will be published on the QPL.

- Please refer to the Level 2 (formerly Family Grouping) Application Requirements for LED-based Horticultural Lighting for specific testing and reporting requirements for product families.

Long-Term Performance

The DLC requires the following performance data to characterize the long-term performance of the fixture:

- **Flux Maintenance, Φ_p (PPF) and $\Phi_{p,fr}$ (PF_{FR})**
  This is a characterization of the ability of the device to maintain its output within the given parameters over time. Given that device output of interest is measured in quanta of photons, and not in lumens, the DLC will use the general engineering term for quanta, "Q", instead of the more-familiar "L" prefix used within general illumination applications.
  - The DLC requires either LED device-level or whole-fixture testing and projections in accordance with the (LM-80 and TM-21) or (LM-84 and TM-28) industry standards sufficient for a Q_{90} of ≥36,000 hours within the Φ_p (PPF) range (400-700nm). The "Q" in the Q_{90} value is based strictly on the value shown in cell I42 of the ENERGY STAR TM-21 calculator or cell I45 of the ENERGY STAR TM-28 calculator.
  - All TM-21 or TM-28 projections shall be made at the maximum ambient temperature on the fixture's specification sheet. See *In-Situ Temperature Measurement Testing (ISTMT)* information below for additional details. All temperature values shall be reported in degrees Celsius.
  - The DLC requires testing and projections to report Q_{90} for the $\Phi_{p,fr}$ (PF_{FR}) range of 700-800nm, but does not make determinations or qualifications based on this data. Please see a description of PFM_{FR}-specific testing requirements in the For fixtures using multiple types of LEDs section below.
  - To support PFM_P and PFM_{FR} projections, LM-80/LM-84 information shall be provided for both the 400-700nm and the 700-800nm range.
    - All new product submissions using the LM-80/TM-21 approach shall provide LM-80 data in appropriate (PPF, PF_{FR}) units, measured as such at all time points in the LM-80 procedure. The DLC reserves the right to request additional information for all reports referring to "photon flux" that are ambiguous (based on product SQD) about the division of said flux between the PPF and PF_{FR} categories to determine approval.
    - Products will not be qualified and listed on the QPL without long-term performance data for flux degradation. Products that use LEDs for which no LM-80 data is available shall undergo LM-84 testing for TM-28 projections.
  - *In-Situ Temperature Measurement Testing (ISTMT):*

- ISTMTs shall be conducted and provided for the hottest LED in the fixture, and LED-device level drive current shall be reported.
- ISTMTs shall be conducted and reported in the same manner as thermal testing for safety certification. Specifically, applicants shall report the operating temperature of the LED at the fixture's highest rated ambient temperature within the ISTMT report. This must be done in accordance with acceptable procedures from safety certification standards for measuring and projecting operating temperatures. For example, if a fixture is rated for operation at 40°C ambient, ISTMTs are not accepted if they only show the temperature of the LED when measured during a 25°C ambient condition. In this example, appropriate steps must be taken to characterize the LED operating temperature when the fixture is in a 40°C ambient environment, as defined by the thermal portions of the relevant safety standards.

- For fixtures using multiple types of LEDs:
  - LM-80 reports (if being used instead of whole-fixture LM-84 data) shall be provided for each type of LED device present in the fixture.
    - For DLC evaluations, LED "type" is differentiated by the nominal output of the LED device or the manufacturer of that LED device. For example, a fixture incorporating four different LEDs, with nominal emissions of 440nm, 660nm, 730nm, and a 5000K "white", is required to provide four LM-80s and associated information for TM-21 projections, corresponding to each of these nominal designations. Some limited cross-applicability of LM-80 data is allowed within phosphor-converted white LEDs of the same series; see LM-80 applicability information below.
  - ISTMT testing shall be provided on the hottest of each LED type (for example, the hottest blue, white, and red LED in the fixture, respectively).
  - Maximum LED drive current shall be reported for each LED type.
  - For PFM_P (400-700nm), each LED type present in the fixture that has at least 25% of its per-device flux in the PPF range shall independently meet the $Q_{90} \geq$ 36,000 hours requirement, as shown by a TM-21 calculation. The DLC does not require device-level SQD data from applicants and will typically accept the applicant's descriptions of a device's relative PPF while reserving the right to request explanation.
  - The DLC requires calculated PFM_{FR} for all fixtures with a PF_{FR} output that is equal to or greater than 5% of the fixture's flux from 400-800nm. For PFM_{FR} (700-800nm), each LED type present in the fixture that has at least 25% of its per-device flux in the PF_{FR} range shall report its Q_{90} duration in hours. The DLC does not require device-level SQD data from applicants and will typically accept the applicant's descriptions of a device's relative PF_{FR}, while reserving the right to

require explanation. There is no threshold performance requirement across this far-red range; it is a reported value only.

- LM-80 applicability:
  - For phosphor-converted "white" LEDs within the ANSI nominal chromaticity range, the DLC follows the *ENERGY STAR Requirements for the Use of LM-80 Data* published September 2017. Consistent with the ENERGY STAR requirements, for narrow-band emitters, the DLC generally requires an LM-80 for each distinct nominal product (e.g., 650nm, 620nm, 590nm) offered by an LED device manufacturer. Devices of the same type but with different optical codes for beam spread are allowed to cross-apply LM-80 testing. This also applies to products that are in the same series with differences in nomenclature due to marketing changes (see series provisions of ENERGY STAR requirements document). The DLC reserves the right to require additional information to approve all claims of LM-80 applicability.

- **Driver ISTMT**

  Applicants shall supply a technical specification sheet for the driver(s) they use in their product, showing the lifetime of the driver based on operating temperature and the temperature measurement point (TMP) for monitoring the operating temperature of the driver. In-situ temperature measurement testing shall be conducted, and a report shall be provided with the application showing an operating temperature consistent with the driver specification sheet information and demonstrating that the driver will have a lifetime of at least 50,000 hours when operating at or above the highest rated ambient temperature on the fixture's specification sheet. All temperature values shall be reported in degrees Celsius.

  As noted in the ISTMT description within the flux maintenance section, driver ISTMTs shall be conducted and reported in the same manner as thermal testing for safety certification. Specifically, applicants shall report the operating temperature of the driver at the fixture's highest rated ambient temperature within the ISTMT report. This shall be done in accordance with acceptable procedures from safety certification standards for measuring and projecting operating temperatures. For example, if a fixture is rated for operation at 40°C ambient, ISTMTs are not accepted if they only show the temperature of the driver when measured during a 25°C ambient condition. In this example, appropriate steps must be taken to report the driver operating temperature when the fixture is operating in a 40°C ambient environment, as defined by the thermal portions of the relevant safety standards.

  - For products that may use multiple drivers, specification sheets for each driver shall be provided with the details above. Testing shall be conducted on each driver at its appropriate worst-case input voltage. If a product uses multiple drivers from the same manufacturer product line or series, as determined by the DLC, then the single worst-case thermal ambient environment of the product line or series requires a driver ISTMT. Typically, the DLC will operate with the expectation that the operating condition at the highest wattage in the driver manufacturer's product line or series is the worst-case thermal ambient environment, but the DLC may ask the manufacturer to provide detailed evidence to document the worst-case driver thermals.

- Custom and integrated drivers shall provide documentation equivalent to that required for drivers from third-party vendors. Manufacturers shall supply documentation indicating the maximum acceptable temperature for the driver for 50,000-hour life, as well as the TMP to be used during thermal testing and evaluation.

- **Fans**

  Products that employ on-board cooling fans shall provide a technical specification sheet for each fan type employed in the product, family group, or spectral sub-group, as applicable. The fan specification sheet shall state the lifetime of the fan and a reference operating temperature rating for that lifetime claim. The lifetime shall be at least 50,000 hours, at an operating temperature at or above the fixture's highest rated ambient temperature.

  If the product is available with multiple fan models:

  - If fan model variations result in substantively different component temperature or wattage consumption by the fixture (determined at the DLC's discretion), a Level 2 (formerly Family Grouping) application is required with model numbers to represent the different fan variations. DLC reviewers will examine fan model power levels and flow rate to determine this distinction. Products that offer fan variations without substantively different component temperature or wattage consumption by the fixture are allowed to qualify using bracketed variations within a single model number.
  - Multiple fan variations require a similar testing and reporting plan to multiple driver variations, as noted in the efficacy section.

- **Warranty**

  Products shall have a manufacturer-provided product warranty of at least five years for fixtures and three years for lamps. The warranty terms and conditions shall be provided as part of the submittal for qualification. The warranty shall cover the complete luminaire and must clearly explain the terms and conditions associated with the warranty. Note that "luminaire" includes light source, housing, heat sink, power supplies, and other electrical components, optics, and any other components such as cooling fans or controls (if present).

  Warranty terms and conditions can vary widely from manufacturer to manufacturer. The DLC explicitly defines a warranty period of five years for fixtures and three years for lamps and does not have specific requirements for warranty claim terms (e.g., labor, recommissioning, etc.) other than those listed above. The DLC does not verify or validate a manufacturer's terms, conditions, or process for customer warranty claims. The DLC does not monitor field failure rates of qualified products, or warranty policy redemption or history among manufacturers. Industry stakeholders are urged to review warranty terms and conditions as part of the purchasing decision process.

Electrical Performance/Power Quality

The DLC requires testing and reporting of the following items to characterize the electrical performance of the fixture:

- **Power Factor**
  Products shall have a measured power factor of ≥0.90 at any rated input voltage at full output or non-dimmed state.

- **Total Harmonic Distortion, current (THDi)**
  Products shall have a measured THDi of ≤20% at any rated input voltage at full output or non-dimmed state.

For products with driver variations, including input voltage variations, electrical testing of each product shall be performed, sufficient to characterize the power quality of each driver, at its applicable nominal input voltages and maximum designed output power. Testing to demonstrate that products are compliant with the power factor and total harmonic distortion requirements may be done on an in-house or benchtop setup for practical simplicity, and results shall be documented and included in the application materials. Please see the Efficacy section for more information on the use of this electrical testing for worst-case efficacy driver variation determination. Please refer to the Level 2 (formerly Family Grouping) Testing Requirements for LED-based Horticultural Lighting for specific testing and reporting requirements for product families.

Safety

Products shall be certified by an OSHA NRTL or SCC-recognized body to ANSI/UL 8800 (ANSI/CAN/UL 8800) which is applicable for *horticultural lighting products* by that safety organization.

Application Information Requirements

Rationale

Version 3.0 Draft 1 proposes that applicants report product-level application-oriented information to support developments in energy efficiency programs (e.g. midstream programs) and stakeholders looking to better identify and compare QPL listed products (e.g. growers directed to the QPL by their local efficiency programs to review and select products eligible for incentives).

Understanding that lighting technology and strategies in controlled environment agriculture (CEA) are continually advancing, Version 3.0 Draft 1 proposes that applicants report the intended controlled environment and lighting scheme for listed products per **Table 3**. Multiple intended controlled environments and/or lighting strategies may be reported for a single listed product.

Table 3: Application Information Reporting Requirements

Controlled Environment		Lighting Scheme		Requirement Type	Method of Measurement/ Evaluation
Indoor	**(Stacked)**	Top light, intra-canopy, other (text)	Sole-source or Supplemental	Reported	Product specification sheet*
	(Non-stacked)				
Greenhouse		Top light, intra-canopy, other (text)	Sole-source or supplemental	Reported	Product specification sheet*

* For verification and evaluation, the respective application information must be clearly stated on the provided specification sheet for each product.

Controlled Environment

The DLC considers controlled environments to be buildings or structures wherein electric lighting and other inputs (e.g., air temperature, humidity, and water consumption) can be controlled to grow crops.

The following are controlled environments considered in Version 3.0 Draft 1:

- **Indoor (Stacked or Non-stacked)**
  Indoor controlled environments are fully enclosed controlled environments with stacked or non-stacked layers.
  - Stacked indoor controlled environments are typically synonymous with vertical farms, and products listed in this controlled environment should be intended for crops that have a short stature, short production cycle, and high yield. Products intended for stacked indoor controlled environments are often highly customizable and scalable.
  - Non-stacked indoor controlled environments are indoor facilities with a single canopy, that do not have multiple vertical layers of crops. Products listed in this category may be intended for a broader variety of crops with varying stature, production cycle, and yield.
- **Greenhouse**
  Greenhouse controlled environments rely on sunlight as a primary light source, but often require supplemental electric lighting (defined below) while still taking maximum advantage of available daylight throughout the year to maintain consistent daily light integral (DLI) incident on the plant canopy. For a variety of reasons, greenhouse controlled environments may require sole-source electric lighting (defined below).

The controlled environment(s) for which the product is intended shall be explicitly and clearly stated in the product specification sheet.

Applicants shall report fixture physical dimensions and a representative image of the fixture (.png format at least 1000 pixels by 1000 pixels), or an active link to the manufacturer website on the QPL for all listed products.

Lighting Scheme

Along with the controlled environment information above, applicants shall report the intended lighting scheme of listed products. Lighting schemes provide insight into how listed horticultural lighting fixtures are intended to deliver optical radiation to the crop/canopy.

The following are lighting schemes considered with Version 3.0 Draft 1:

- **Sole-Source and/or Supplemental**
  Products reported to be sole-source shall be intended for applications where the lighting fixture is the primary source of optical radiation for inducing photobiological effects in crops.

  Products reported to be supplemental shall supplement daylight and shall be intended for applications where the lighting fixture is not the primary source of optical radiation for inducing photosynthesis, but is instead intended to supplement a separate primary light source and overall energy usage is not as high (e.g. a specialty lamp that is intended to provide specific spectra to induce a specific growth action in addition to sunlight in a greenhouse or a higher output product with a broader spectra to fully supplement daylight in a northern environment).

- **Top light, Intra-canopy, or Other (text)**
  Top light, intra-canopy, or other (text) are required reported information to convey the direction that listed products deliver optical radiation.

  Products reported to be a top light shall be intended to be mounted with the emission area facing down, toward the canopy.

  Products reported to be an intra-canopy light shall be intended to be mounted within the canopy.

  To account for innovative technologies in this developing field, the “other (text)” option supports products that do not fit within the top lighting or intra-canopy lighting categories. For instance, “other (bottom lighting)”.

The lighting scheme(s) for which the product is intended shall be explicitly and clearly stated in the product specification sheet.

Key Questions for Application Information Requirements Section

Version 3.0 Draft 1 proposes specific controlled environments and lighting schemes to be reported on the QPL for listed products.

1. Should the DLC include “residential” as a reported controlled environment option? If so, what lighting scheme options should be considered for residential controlled environments for Draft 2?

2. Considering existing and/or anticipated CEA applications, are there controlled environments or lighting schemes that are not covered by Draft 1? If so, please specify these applications and provide terminology recommendations for consideration in Draft 2.
3. What additional information should be potentially required and/or reported to relate listed products to the application(s) they are intended to operate in?

Controllability Requirements

Rationale

Version 3.0 Draft 1 establishes a new set of controllability testing and reporting requirements for horticultural lighting products that allow for increased versatility and energy savings within CEA environments. The DLC proposes a requirement that all products be capable of dimming. Dimmable products have the potential to save energy, lay the groundwork for demand response programs, and prevent over-lighting. Draft 1 also introduces new reporting requirements to promote interoperability between horticultural luminaires and control systems by representing how each product is controlled on the QPL.

Controllability requirements are outlined in **Table 4**. Details explaining each item follow Table 4.

Table 4: Controllability Requirements

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
Dimming Capability	All products shall have the ability to dim	Required	Product specification sheet*
Dimming Range	n/a	Reported	Product specification sheet or supplemental documentation*
Dimming and Control Method Designations to the Product	n/a	Reported	Product specification sheet or supplemental documentation*
Control Attributes	n/a	Reported	Product specification sheet or supplemental documentation*
Connector / Transmission Hardware	n/a	Reported	Product specification sheet or supplemental documentation*

* For verification and evaluation, the corresponding characteristic must be clearly stated on the provided specification sheet for each product and/or supplemental material as specified above. There will be no further evaluation against any other standards. For DC powered products, this information may also be included on the specification sheet for the power supply, if applicable.

Dimming Capability

Products shall be capable of dimming through a line voltage, low voltage, or wireless signal. For verification, the product technical specification sheet (or other documentation noted below **Table 4**) shall state that the product is dimmable.

Dimming Range

To describe the dimming range of the product, each of the following values shall be reported and included on the product specification sheet and/or supplemental documentation:

- The input power (in Watts) to the product at the minimum dimming level, expressed as a percentage of the maximum power.
- The minimum dimming level, expressed as a percentage of the maximum PPF.
    - If the product is capable of being turned off via the control signal (dim to off), this field may be reported as "0%".
- The default PPF in units of µmol × s^{-1}.
    - The default PPF occurs at the default setting, at which the product is shipped with no adjustments.
    - If no default PPF is provided on the product specification sheet or supplemental material, it is assumed that the default PPF is the same as the maximum PPF.

Dimming and Control Method Designations to the Product

All available dimming and control method designations between the product and other devices shall be reported and stated on the product technical specification sheet or supplemental documentation (noted under **Table 4**). Options for reporting are included in **Table 5**. The "Acceptable Terms" column includes terms that may appear on the provided documentation to indicate the use of the corresponding dimming or control method. Multiple selections may be made.

If multiple drivers are offered for a single product, each with a unique dimming or control method, these options may be bracketed into a single line item on the QPL. However, model numbers must still indicate specific dimming or control methods available. Multiple dimming or control methods may not be represented by an asterisk or other generic character in a single model number if driver or product changes are necessary to achieve the method of control (the DLC refers to this type of representation as "wildcarding").

Exceptions may be made for DC-powered products and replacement lamps. For further information, see Special Considerations below.

Table 5: Dimming and Control Method Designations to the Product

Control Type (as displayed on the QPL)		Definition	Acceptable Terms
Wired	**0-10V IEC 60929 Annex E**	Wired analog low-voltage control that varies DC voltage between 0 and 10 volts (or 1 and 10 volts) to produce varying light output.	0-10V, 1-10V, 10V, 10V0
	0-10V ANSI C137.1-2019 (8-Volt)		
	0-10V ANSI C137.1-2019 (9-Volt)		
	0-10V Other		
	DALI	Digital Addressable Lighting Interface Protocol, a wired digital communication protocol registered by the DALI alliance.	DALI
	DALI2		DALI2, DALI-2
	Other Wired	Other wired communication protocol as specified by the manufacturer.	N/A
Wireless	**Zigbee**		
	Zigbee 3.0	Wireless digital communication protocol developed by the Connectivity Standards Alliance.	Zigbee 3.0, ZB3
	Zigbee – Manufacturer Specific		ZigBee
	Bluetooth		
	BLE MDP v2	Wireless digital communication protocol developed and maintained by the Bluetooth Special Interest Group (SIG).	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
	Wi-Fi	Wireless networking protocol based on IEEE 802.11.	Wi-Fi, WIFI, IEEE 802.11, Wi-Fi Certified
	EnOcean	Wireless digital communication protocol developed by EnOcean.	EnOcean
	Other Wireless	Other wireless communication protocol as specified by the manufacturer.	N/A

Control Attributes

All available control attributes listed in **Table 6** shall be reported. If applicable, this information shall be included on the product technical specification sheet or supplemental documentation (noted under **Table 4**) with one or more of the terms from the "Acceptable Terms" column. Multiple selections may be made. If a product does not include any of the attributes in **Table 6,** this field may be left blank.

Table 6: Control Attributes

Control Attributes	Definition	Acceptable Terms
Dim to Off	The ability for a product to be turned on or off via a dimming control signal.	Dim to off, Dimming: 0%-100%
High End Trim	The capability to set the maximum light output to a less-than-maximum state of an individual luminaire/lamp at the time of installation or commissioning. High-end trim must be field reconfigurable.*	High-End Trim, Task Tuning
Energy Monitoring	The capability of a system to report the energy consumption of a luminaire/lamp.	Power/Energy Monitoring, Power/Energy Metering, Power/Energy Measurement Power/Energy Reading
Manual Dimming	A knob or other control device integrated into the fixture used for manual dimming.	Manual Dimming, Knob Dimming, Dimming Knob, Fixture Integrated Dimming, Dimming Switch

* In addition to the presence of acceptable terms, product submissions that report high end trim will be evaluated to ensure that high end trim is field reconfigurable, and that this is clearly represented on the product specification sheet or supplemental material.

Connector/Transmission Hardware

The connector/transmission hardware is the hardware integrated into the product that enables it to physically connect with and receive signals from a controller or other device. All available connector/transmission hardware shall be reported and stated on the product technical specification sheet or supplemental documentation (noted under **Table 4**) using one or more of the terms from the "Acceptable Terms" column in **Table 7**. Options for reporting are listed below. Multiple selections may be made. If variations are offered for a single product, each with a unique connector/transmission hardware option, these options may be bracketed into a single line item on the QPL.

Table 7: Connector/Transmission Hardware Options

Connector / Transmission Hardware		Acceptable Terms
Wired	**RJ-11**	RJ-11, RJ11
	RJ-12	RJ-12, RJ12
	RJ-45	RJ-45, RJ45
	Terminal Block	Terminal Block
	Other Wired	N/A
Wireless Radio		Wireless, Bluetooth, BLE, Wi-Fi, WIFI, IEEE 802.11, Zigbee, EnOcean

Key Questions for Controllability Requirements Section

1. Draft 1 proposes that all products qualified under V3.0 shall be dimmable. Is this requirement reasonable? If not, what is the value proposition for non-dimmable products?
2. Draft 1 proposes to include default PPF as a reported value. This may be valuable in cases where the default PPF is lower than the maximum PPF. Are there products on the market today that are designed this way, or is it standard for products to come with the maximum PPF as the default?
3. Table 5 aims to capture the dimming and control method designations that are prominent in horticultural lighting products. Are there any dimming or control method designations or additional attributes used in horticultural fixtures that are not listed here and would be valuable to include in Table 5 (e.g., DMX or other Zigbee classifications)? For those that are listed in Table 5, are the acceptable terms provided sufficient?
4. Table 6 aims to capture the prominent control attributes that are important for interoperability and design considerations. Are there any control attributes not listed in Table 6 that would be valuable to include and list on the QPL?
5. Draft 1 proposes to include connector/transmission hardware as a reported attribute. Should this information be captured and listed on the QPL, and if so, a) are the acceptable terms provided sufficient or are more needed, and b) are there any connector/transmission hardware options not listed here that are commonly used in horticultural lighting?
6. In the Special Considerations for DC-Powered Products section of this document, the DLC has stated that for DC-powered fixtures that do not specify a power source intended for use, the "Dimming and Control Method Designations to the Product" refers to the method of communication to the fixture. Are there any dimming or control methods that should be added to Table 5 that are used by DC-powered fixtures with an unspecified power source? Are there any other special considerations needed for controllability of DC-powered products that are not captured here?

Special Considerations

Special Considerations for Spectrally Tunable Products

Spectrally tunable products (products with varying output channels beyond simple, single-axis dimming of the whole product) are eligible with the following conditions:

- The threshold-qualifying state to be tested shall be the manufacturer-designed state with the highest power consumption ("maximum power"). This may or may not be the same as an "all channels on" condition since fixtures may not be designed to use all their channels simultaneously. Test reports shall specifically indicate that the product is operated in this "maximum power" condition during the testing, with a description of the control narrative to ensure that the power state is at its maximum designed level.
- In addition to the "maximum power" condition, applicants shall perform PPF testing for each control channel, in which the channel under test shall be set to the maximum designed output, and all other channels shall be set to their minimum designed output for this state. The test report shall present an identifying name of this channel and setting, the PPF (400-700nm total and 400-500nm, 500-600nm, and 600-700nm "bins" PPF) and PF_{FR} (700-800nm) for each of the single-channel scenarios, and a description of the control narrative to achieve each setting. For each channel tested, a corresponding graphic for the SQD produced in that setting shall be provided in the application. Refer to the SQD section for reporting requirements.
    - The flux output of each specific channel testing is displayed on the DLC Horticultural QPL, with the per-channel test outcomes and identifying information for each setting. These data are intended to support standardized communication of information about the product's spectral tuning range, aiding product selection and user acceptance.
- Applicants shall provide user-facing documentation narrating the control protocol and input parameters employed in controlling the output and shall comply with the Controllability Requirements listed above.
- For PFM_P and PFM_{FR} evaluation:
    - Provisions for products utilizing multiple types of LEDs shall be followed as described in the For fixtures using multiple types of LEDs section.
    - ISTMT testing shall be provided on the hottest of each of the LED types. For each unique LED type, ISTMT testing shall occur at the operating mode that produces the highest operating temperature in the fixture for this LED type. Test reports shall specifically indicate that the product is operated in this "highest operating temperature" condition during the testing, with a description of the control narrative to ensure that the power state is at its highest operating temperature designed level.
    - The DLC asks any applicants considering LM-84-based maintenance testing on a spectrally tunable fixture to contact horticulture@designlights.org to discuss their proposed testing plan.

Special Considerations for DC-Powered Fixtures

Eligibility Information

Horticultural lighting fixtures powered by direct current (DC) are eligible for listing on the Horticultural QPL. DC-powered fixtures include two types:

- **Modular and/or dynamically configurable fixtures where one or several AC-to-DC power sources supply power to multiple fixtures/modules.** The power source(s) may have a minimum as well as a maximum number of fixtures that they may serve. The AC-to-DC power source(s) may be attached to one of the fixtures or may be located remotely from the fixtures. The power source(s) must be marketed by the fixture manufacturer as the intended power source(s) for that specific fixture model or family.
- **Fixtures that operate on DC power, where an AC-to-DC power source is not marketed by the fixture manufacturer as the intended power source.** These fixtures may be wired to an AC-to-DC power source outside the fixture or in a separate room, or may be part of a DC-only horticultural facility.

Technical Requirements for DC-powered Fixtures

All V3.0 Horticultural Lighting Technical Requirements described in **Table 1** shall be met in addition to the following requirements, with exceptions as noted. The following requirements apply to applications for DC-powered fixtures, in place of the equivalent AC testing and reporting:

- **DC-powered "all-on" photon flux test report**: Applicants shall provide an LM-79 report in PDF format from an accredited third-party test lab with all required photon flux and power values for verification, including DC voltage, current, and power. This is the test report of the product at the maximum (non-dimmed) power state of the product.
- **Power source test report**: If power sources are marketed with the DC-powered fixture, applicants shall provide a table of the following performance values for all power sources offered for sale with the DC fixture. These values may come from benchtop testing (measurements performed by a manufacturer that are not from a certified testing lab). All values shall be provided at the reported minimum and maximum AC input voltages for each power source, as well as at each DC output voltage utilized by the DC-modular fixture (if multiple). A power source specification sheet or other documentation from the power source manufacturer with numerical values listed for each load point may satisfy this requirement, in place of testing.
    - Performance values shall be provided at each of two load points as determined by the fixture manufacturer:
        - Maximum power load, i.e., the load representing the maximum number of light fixtures that can be powered by this power source.
        - The load point of the power source between maximum power load and 20% of maximum load that results in the worst-case power source efficiency.

- Only load points achievable with multiples of this fixture at full output need to be considered in identifying the worst-case power source efficiency. For example, for a 100W power source that may power either two or three 30W fixtures, only the 60% and 90% loading conditions need to be compared to determine the worst-case efficiency.
- A lower limit on load points may also be set by the loading requirement for a given power source listed on the fixture specification sheet. For example, "required operating range of 15-90W output at 100W input power."

- The following performance values shall be reported in the power source test report:
  - Nominal AC input voltage
  - Maximum output power of the power source at the specified input voltage, shown to the nearest watt
  - Minimum and maximum output power for the specific combination of power source and horticultural fixture at full output, shown to the nearest watt
  - Loading percentage (the ratio of tested DC output power to maximum output power with this fixture), shown to the nearest tenth of a percent
  - Tested AC input power, shown to the nearest hundredth of a watt
  - Tested DC output power, shown to the nearest hundredth of a watt
  - Electrical efficiency (power source output power divided by power source input power), shown as a percentage to two decimal places
  - Power factor, shown to three decimal places
  - Total harmonic distortion of the current waveform as a percentage, shown to one decimal place
- The following example shows this table for a single power source:

Manufacturer Name			**Model Number**				**AC Input Voltage Range (V)**		**DC Output Voltage Range (V)**	
ABC Corp.			*ABC123*				*120-277*		*48*	
Nominal AC Input Voltage (V)	**Power Source Maximum Output (W)** [Output rating irrespective of fixture]	**Minimum Output Power with this fixture type (W)** [fixture type at full output]	**Maximum Output Power with this fixture type (W)** [fixture type at full output]	**Loading Scenario**	**Loading Percentage (%)** [Relative to maximum for this fixture type-power source combination]	**Tested AC Input Power (W)**	**Tested DC Output Power (W)**	**Tested Efficiency (%)**	**Power Factor**	**Total Harmonic Distortion (current) (%)**
120	3100	300	3000	Full	**100.0**	3115.23	3000.00	96.30	0.932	5.0
				Worst-Case Efficiency	**20.0**	677.63	600.00	88.54	0.914	4.0
277	3100	300	3000	Full	**100.0**	3098.02	3000.00	96.84	0.932	5.6
				Worst-Case Efficiency	**20.0**	665.19	600.00	90.20	0.911	5.9

- Fixtures where no AC-to-DC power source is marketed by the fixture manufacturer as the intended power source with any AC-to-DC power source are not required to provide a power source test report. These products will be listed with an assumed AC-to-DC conversion efficiency (see below).

- **Power source ISTMT report**: Consistent with the Horticultural Technical Requirements for drivers, power source ISTMT reports are required for all horticultural products sold with AC-to-DC and DC-to-DC power sources, as applicable. DC-to-DC power source ISTMT reports are required for both DC fixture types described in the "Eligibility Information" section above.
    - DC-to-DC power sources include any component that modifies the current or voltage input to the LED chips, either in value relative to input (e.g., a voltage converter) or value over time (e.g., a constant current power source).
    - AC-to-DC power sources, in the context of DC-powered products, include components external to the listed product that convert AC power to DC power.
- **Information or specifications for DC cabling**: Manufacturers shall provide information or specifications for DC cabling on the fixture specification sheets or supplemental marketing documentation. Guidance for maintaining cabling losses to less than 2% for a fully loaded power supply shall be detailed.
    - The fixture wattage in the cabling guidance shall match the input power of the submitted fixture, and the cabling losses shall reflect the copper resistance values listed in NFPA 70 National Electrical Code, 2020 Edition. Applicants may choose their own tradeoff of cabling gauge and length, as long as it conforms with cabling information provided on the fixture specification sheet.

Controllability Interactions with DC-specific Requirements

All controllability requirements from **Table 4** shall be met, with the following adjustments and clarifications:

- For DC-powered fixtures that utilize a specific central AC to DC power source marketed for use with the product, the "Dimming and Control Method Designations to the Product" refers to communication between the power supply and the dimming controller. The options from **Table 5** apply.
- In cases where no power source is marketed for use with the product, "Dimming and Control Method Designations to the Product" refers to the signal received by the product. The options from **Table 5** apply.
- For wired DC-powered fixtures that utilize a central AC to DC power source, the "Connector/Transmission Hardware" refers to the port or terminal on the fixture that a control cable connects to.

QPL Listing Information for DC-powered Fixtures

DC-powered fixtures will be listed on the Horticultural Lighting QPL with the following differences from AC-powered fixtures.

The following new fields will be listed on the QPL. Unless noted below, all DC numerical fields below will have an equivalent tested value and reported, or nominal, value provided by the submitter in the review.

- **"Input Power Type"** will be distinguished between AC and DC products.

- **"Tested Voltage"** and **"Tested DC Input Current"**, from the all-on DC-powered LM-79 photon flux report for both DC-powered fixture types. Nominal values for "Reported Maximum Input Voltage", "Reported Minimum Input Voltage", and "Reported DC Input Current", are provided by the submitter during application submittal.
- "**DC Input Wattage"** and **"DC Photosynthetic Photon Efficacy (µmol/J) (400-700nm)** will display the values from the all-on DC-powered LM-79 photon flux report.
    - Optional new field **"DC PE_{PBAR} (µmol/J) (280-800nm)"** will be reported if "DC PF_{PBAR} (µmol/J) (280-800nm)" is reported.
- New fields will display **"AC De-rated Input Wattage"** and **"AC De-rated PPE (µmol/J) (400-700nm)"** only for DC-powered fixtures.
    - DC-powered fixtures shall meet the PPE threshold requirement at their AC de-rated PPE value.
        - For example, a 100W lightbar with a DC-powered PPE of 2.5 µmol/J and a power source with a worst-case efficiency of 90% at 20% load would be listed on the QPL at 2.25 µmol/J AC De-rated PPE and 105W AC De-rated Input Wattage.
        - The fields currently used for "Photosynthetic Photon Efficacy: 400-700 nm, µmol/J (PPE) (AC)" will not be populated.
    - DC-powered fixtures marketed with any AC-to-DC power source will reflect the power efficiency of the AC-to-DC conversion at the load condition that creates the worst-case efficiency.
        - For example, a 100W lightbar with a PPE of 3.0 µmol/J and a power supply showing a worst-case efficiency of 85% at 20% load, would be listed on the QPL at 2.55 µmol/J and 118W.
    - DC-powered fixtures that are not marketed with any AC-to-DC power source will display values in the AC de-rated fields based on an assumed 87.5% conversion efficiency. 87.5% is informed by the Federal Standard 10 C.F.R. § 430.32(w) for minimum efficiency for external power supplies greater than 250W.
    - Optional new field **"AC De-rated PE_{PBAR} (µmol/J) (280-800nm)"** will be reported if "DC PE_{PBAR} (µmol/J) (280-800nm)" is reported.
    - **"Power Source Loading Percentage"** will display the fixture loading that creates the worst-case efficiency used in the de-rating calculations and the power source load point that creates that worst-case condition, in the format "AC-derated performance is 91.12% efficiency at 20% loading on a 3000W power source at 120V."
- **"Cabling Loss Example"** will show an example of cabling length and gauge that results in cabling losses less than 2% for a fully-loaded power supply.
    - For example: "Nine 300W fixtures parallel-wired with 100 feet of 10AWG cabling to a 3,000W power supply channel."
    - This field will be populated only for DC-powered fixtures marketed with an AC-to-DC power source.

- The worst-case values of total harmonic distortion (current) and power factor from the Tested Power Source Table will be shown in the existing fields for **"Total Harmonic Distortion"** and "**Power Factor**." THDi and power factor fields will be populated only for fixtures marketed with an AC-to-DC power source.

Special Considerations for Externally Supplied Actively Cooled Fixtures

Eligibility Information

LED horticultural fixtures that employ externally supplied circulating liquid are eligible with the following conditions described below.

- The DLC defines externally supplied circulating-liquid-cooled horticultural fixtures to be products in which liquid, often water or a water/glycol solution, flows through input and output ports of each fixture in the system, being channeled through a cooling plate or other heat exchanger within the fixture.
- LED horticultural fixtures that employ externally supplied ducted forced air are not eligible at this time. For simplicity, Version 3.0 may refer to eligible externally supplied actively cooled fixtures as 'actively cooled'.

Technical Requirements for Externally Supplied Actively Cooled Fixtures

All V3.0 Horticultural Lighting Technical Requirements described in **Table 1** shall be met in addition to the following requirements and clarifications:

- Manufacturers shall specify information regarding allowable operating conditions that affect product performance, including:
    - **Solution type/concentration:**
        - Restrictions or limitations to allowable solution type/concentration shall be described in marketing material/specification sheets and will be reported on the Hort QPL.
    - **Inlet fluid temperature range:**
        - Minimum and maximum allowable operating inlet fluid temperatures shall be stated in marketing material/specification sheets and will be reported on the Hort QPL.
        - Data describing the performance impact of varying inlet fluid temperature on measured PPF and measured input power of the fixture, reported in increments of 5 degrees Celsius (or smaller) covering the complete allowable inlet fluid temperature range, shall be provided. A template file will be available for actively cooled applications to capture this data. The template file will be used to generate and report an image of this data on the QPL.
            - Flow rate shall be held constant across the allowable temperature range and shall be reported.

- Measured PPF as a function of inlet fluid temperature data and measured input power as a function of inlet fluid temperature data shall be provided and will be reported on the Hort QPL.
    - All temperature values shall be reported in degrees Celsius.
- **Self-protect cut-off functionality:**
    - Fail to off functionality shall be present to turn off the actively cooled fixture before a maximum inlet fluid temperature is reached, in the event that the external cooling system fails.
    - Self-protect cutoff temperature shall be stated in manufacturer-provided marketing material/specification sheet and will be reported on the Hort QPL.

- All inlet fluid temperatures shall be maintained within a tolerance of +/- 2.5 degrees Celsius to the target temperature during LM-79 and ISTMT testing.
- LM-79 testing shall employ water as the cooling liquid at an appropriate flow rate to maintain the targeted *median inlet fluid temperature* (i.e., middle operating inlet fluid temperature in the allowable range) as defined by the luminaire manufacturer.
- The average and maximum inlet fluid temperature measured during LM-79 testing (measured at fixture-level stabilization per LM-79), within the allowable 5-degree Celsius range, shall be provided and reported on the Hort QPL.
- ISTMT testing shall employ water as the cooling liquid at an appropriate flow rate to maintain the targeted *worst-case inlet fluid temperature* (i.e., maximum allowable operating inlet fluid temperature) as defined by the luminaire manufacturer. The average and maximum inlet fluid temperature measured during ISTMT testing (at stabilization), within the allowable 5-degree Celsius range, shall be provided and will be reported on the Hort QPL.
- Flow rate, measured in gallons per minute (GPM), shall be recorded during LM-79 and ISTMT testing, with the average and highest flow rate measurements being provided and reported on the Hort QPL.
- Outlet fluid temperature shall be measured during LM-79 testing, with the average and highest outlet fluid temperature reported on the Hort QPL.
- To support the qualification of externally supplied circulating liquid cooled horticultural fixtures, the DLC will accept LM-79 gonioradiometric testing with methods or equipment ranging from Type C goniometers to other gonioradiometer types.
    - All externally supplied circulating liquid cooled horticultural fixtures seeking qualification by the DLC mshall test the fixture per ANSI/IES LM-79, including requirements specific to, but not limited to, stabilization and optical measurements, while employing active cooling.
    - The DLC reserves the right to require additional information on all LM-79 test reports derived from non-Type-C gonioradiometer types.

QPL Listing Information

In addition to the existing fields, externally supplied actively cooled fixtures will have the following information listed on the QPL:

- **"Active Cooling Presence"**
    - Externally supplied circulating liquid cooled horticultural fixtures will be distinguished as "active cooling presence" and will be designated as such on the Hort QPL (e.g., as a filterable field)
- **"Tested Inlet Fluid Temperature"** and **"Tested Flow Rate"**
    - Maximum measured inlet fluid temperatures and flow rates per ISTMT and LM-79 testing
    - Average measured inlet fluid temperatures and flow rates per ISTMT and LM-79 testing
- **"Tested Outlet Fluid Temperature"**
    - Maximum measured outlet fluid temperature per LM-79 testing
    - Average measured outlet fluid temperature per LM-79 testing
- Additional reporting fields, relating to the allowable operating conditions for the system including:
    - **"Solution Concentration Restrictions"**
    - **"Minimum Allowable Inlet Fluid Temperature"** and **"Maximum Allowable Inlet Fluid Temperature"**
    - **"Self-Protect Cut-Off Temperature"**
    - Reported data depicting PPF and wattage as a function of inlet fluid temperature.

Special Considerations for LED Replacement Lamps

Eligibility Information: Linear Replacement Lamps

LED replacements for linear fluorescent lamps are eligible with the following conditions:

- The DLC defines all tube-style LED products that use lamp holders (i.e., sockets or tombstones) in the luminaire to mechanically and/or electrically connect to the fixture housing and electric supply to fall under these testing requirements. Products that do not employ lamp holders are not eligible as lamps under this policy.
- The DLC defines bare lamp as the performance characteristics of a replacement lamp, including the effects of an external ballast (for Type A and Dual Mode lamps) or driver (for Type C lamps), if applicable, when operated outside of a luminaire or retrofit kit.
- The following linear lamp replacement types (i.e., T8, T5, or T5HO) and specific lengths are eligible for listing. Marketing material shall indicate that they are intended to replace fluorescent lamps of the same type and length. Products of different lengths, bases, or marketed as intended to replace other types of fluorescent lamps are not eligible. Products intended to operate on magnetic ballasts or those with different base types are not eligible.

- **T8 Two-Foot Linear Replacement Lamps**
  LED lamps intended to replace T8 fluorescent lamps. These LED lamps shall be 24 inches long and employ a G13 base.
- **T8 Four-Foot Linear Replacement Lamps**
  LED lamps intended to replace T8 fluorescent lamps. These LED lamps shall be 48 inches long and employ a G13 base.
- **T8 Eight-Foot Linear Replacement Lamps**
  LED lamps intended to replace T8 fluorescent lamps. These LED lamps shall be 96 inches long and employ a FA8 base.
- **T5 Four-Foot Linear Replacement Lamps**
  LED lamps intended to replace T5 fluorescent lamps. These LED lamps shall be 46 inches long and employ a G5 base.
- **T5HO Four-Foot Linear Replacement Lamps**
  LED lamps intended to replace T5HO (High Output) fluorescent lamps. These LED lamps shall be 46 inches long and employ a G5 base.

- The following UL Types A, B, Dual Mode (AB) and C are eligible for listing.
  - **Internal Driver/Fluorescent Ballast (UL Type A):**
    Products of this type employ lamp holders to connect to the fixture being retrofitted and are designed to be "plug and play" replacements for fluorescent lamps. That is, products in this category operate utilizing an existing fluorescent ballast, and do not require additional mechanical or electrical changes to the fixture.
  - **Internal Driver/Line Voltage (UL Type B):**
    Products of this type employ lamp holders to connect to the fixture being retrofitted, but do not operate utilizing the existing fluorescent ballast. These products require rewiring of the existing fixture to bypass the ballast and send line voltage directly to the lamp holders.
  - **Dual Mode Internal Driver (UL Type A and Type B):**
    Products of this type can either use the existing fluorescent ballast or be operated using line voltage if the fixture is rewired to bypass the ballast. These products connect to the fixture using standard lamp holders.
  - **External Driver (UL Type C):**
    Products in this category employ lamp holders to connect to the fixture being retrofitted. They do not use the existing fluorescent ballast and require rewiring of the existing fixture to replace the ballast with an external driver (i.e., the driver is internal to the fixture but external to the lamp). The lamp holders are then wired to connect to the external driver. For Type-C lamp systems with non-identical lamps, refer to the *Special Considerations for Linear Replacement Type-C Lamp Systems with Non-Identical Lamps* as written in the SSL Testing and Reporting Requirements for Linear Replacement Lamps.

Testing Notes: Linear Replacement Lamps

For Type A and Dual Mode Type A/B linear replacement lamps designed to operate on an existing fluorescent ballast, the PPE, PPF, and wattage performance shall represent the combined lamp + ballast system. LM-79 testing shall be conducted using a ballast consistent with **Table 8**. Specification sheets for

the ballast used during testing shall be provided with the application and the ballast make and model number shall be noted in the test report. Ballasts used in testing shall be certified to the applicable safety standards and shall comply with applicable ANSI standards.

Table 8: Type A and Dual Mode Reference Ballast Criteria

General Applications	Reference Ballast for Type A and Dual Mode Type A/B
T8 Linear Replacement Lamps	T8 electronic instant-start ballast with 0.88 ballast factor
T5/T5HO Linear Replacement Lamps	T5/T5HO electronic programmed-start ballast with 1.0 ballast factor

For Type-B and Type-C products (i.e., lamp-style retrofit kits, which connect mechanically and/or electrically to the fixture via standard lamp holders, but which require an electrical modification to the existing fixture), "lamp"-level testing is also required.

If the system is designed to operate multiple lamps utilizing an external driver, the driver shall be loaded as it would be in the field, with appropriate steps taken to calculate the PPE of the single lamp. For example, for a two-lamp kit, one lamp should be measured for PPF, while the system as intended (with two identical lamps on the driver) should be measured for electrical input. The wattage into the driver can then be divided by two, and that wattage divided into the lamp lumens to determine system PPE.

Appropriate steps to measure the electrical and photometric properties of the lamp system, under most circumstances, would be to load the driver or ballast appropriately, then isolate a single lamp in the apparatus being used for photometric measurements. In a sphere, for example, this could be accomplished by placing one lamp from the system inside the sphere, while the other one is outside the sphere.

Goniophotometric testing of bare lamps is also required for verification of beam angle. Understanding that it may be challenging to properly isolate a single lamp from a multi-lamp system in a goniophotometer, the DLC will accept testing that conforms to the LM-79 standard and operates the lamp directly on DC power, eliminating the external driver or ballast from the system. The only results of this test that will be used in the application review will be the candela array for calculations of beam angle. All other measurements will not be used in the application review.

If testing using this method:

- The power supplied by the lab power supply to the lamp should match that which the lamp would receive from the ballast or external driver.
- A separate LM-79 report from an integrating sphere shall be provided on the lamp under test.
- The goniophotometric test report shall explicitly and clearly state the test conditions (i.e., without driver/ballast).

For questions, please contact horticulture@designlights.org.

Eligibility Information: Screw-Base Replacements for HID Lamps

LED replacements for mogul-base high intensity discharge (HID) lamps are eligible with the following conditions:

- The DLC accepts Horticultural QPL applications for mogul (E39 and E40) screw-base replacement lamps. Only UL Type B products, which require removal of the existing ballast from the circuit and the lamp holder to be wired with line voltage, are eligible.
    - Other base types and UL Types are not eligible at this time.
    - Lamps with field adjustable light distribution (FALD) are not eligible at this time.

Technical Requirements Information: All Replacement Lamps

All replacement lamps seeking horticultural lighting qualification shall test the bare lamp according to LM-79 to meet all V3.0 Horticultural Lighting Technical Requirements for fixtures as described in **Table 1**, except for driver lifetime and a five-year warranty. These exceptions are described below:

- Instead of driver lifetime:
    - Lamps shall have a lifetime of at least 50,000 hours.
    - Lamps shall perform an In-Situ Temperature Measurement Test (ISTMT) and report at the product's highest rated ambient temperature using a location on the lamp body, which will have the highest temperature of any point on the lamp during normal operation, designated by the manufacturer to correlate to the lifetime with the lifetime of the lamp.
    - Applicants shall supply a technical specification sheet for their product, showing the lifetime based on the given location's operating temperature and an image/diagram showing the temperature measurement point (TMP) location on the lamp body for monitoring the operating temperature.
    - In-situ temperature measurement testing shall be conducted, and a report shall be provided with the application showing an operating temperature measurement point (TMP) consistent with the specification sheet information and measured temperature demonstrating that the lamp will have a lifetime of at least 50,000 hours when operating at or above the highest rated ambient temperature on the lamp's specification sheet.
- Instead of a five-year warranty:
    - LED replacement lamps shall have a manufacturer-provided product warranty of at least three years. All other requirements of warranty described in this document still apply to lamps.

In addition to meeting all V3.0 Horticultural Lighting Technical Requirements for fixtures (except those noted above), lamps shall meet the following additional requirements:

- All replacement lamps shall report beam angle during the application process. This information will be displayed on the QPL.

- All replacement lamps shall report product size information (length, width, height, diameter, as applicable) on the technical specification sheet. This information will be displayed on the QPL.

Controllability Interactions: All Replacement Lamps

As with all other types of horticultural products, LED replacement lamps shall be dimmable. Because lamps are most often used in retrofit applications, there are special considerations needed to ensure end users can dim lamps as desired. The following considerations apply to each UL Type of linear replacement lamps and mogul-screw base lamps, as appropriate:

UL Type A

- With the exceptions noted below, Type A lamps capable of wired dimming solely via input from the existing ballast should enter "Other; Dimmable depending on ballast capability" in the "Dimming and Control Method Designations to the Product" field, as wired control signals are received by the ballast and not the lamp itself. All other fields should be filled in as applicable.
    - Due to the lack of dimmable ballasts available in the marketplace for eight-foot T8 fluorescent lamps, Type A, T8 eight-foot lamps that claim wired dimming capability utilizing the direct input from the ballast to achieve dimming will be rejected.
    - Any Type A lamps which do not solely utilize the ballast input to achieve dimming capability through a wired dimming or control method (i.e., the dimming control wires connect directly to the lamp) shall report the specific wired dimming or control method and provide a wiring diagram.
        - For the two exceptions above, if an external device is used between the dimming control user interface and Type A lamp, then these lamps will be classified as "Other Wired: Input Signal from External Control Source" and should indicate this on the application form in the "Dimming and Control Method Designations to the Product" field as "Other Wired: Input signal from external control source". The wiring diagram noted above will be evaluated by reviewers to determine if an external device is required to achieve the specific dimming or control method.

UL Type B

- In addition to reporting dimming capability, dimming range, presence of control attributes, and dimming and control method designations, Type B lamps that claim to be dimmable via a wired dimming or control method with 0- 10V or DALI shall provide a wiring diagram in the product specification sheet, installation instructions, or separate document showing the electrical circuit of the lamp connecting to mains power, including the location of the input signal from an external control source to the lamp or lamp holder for 0-10V or DALI control.
- Type B lamps listed for operations with 0-10V or DALI communication control shall be able to achieve this dimming capability without an external signal converter and the low voltage control wires shall connect directly to the lamp or lamp holders.
    - If an external device is used to receive the 0-10V or DALI control signal, then these lamps will be classified as "Other Wired" and should indicate this on the application form in the "Dimming and Control Method Designations to the Product" field as: "Other

Wired: Input signal from external control source". The wiring diagram noted above will be evaluated by reviewers to determine if an external device is required to achieve the specific dimming or control method.

UL Type A/B Dual Mode

- Type A/B shall be dimmable in both modes of operation and stated as such on the product specification sheet.
- Everything from UL Type A above applies to UL Type A/B Dual Mode. All products will have a note on the QPL that says: "When operated as Type A, dimmable depending on ballast capability"
- Similarly, Dual Mode Lamps shall supply documentation as noted in the Type B section above and will be listed on the QPL as described for Type B lamps. If the Type B lamp accomplishes dimming with an external accessory, it will include a note that is specific to Type B operation.

UL Type C

- Type C lamps must meet all V3.0 controllability requirements with no further considerations.

Technical Requirements Information: Screw-Base Replacements for HID Lamps

Screw-base replacements for HID lamps can be generally omni-directional (the DLC defines omni-directional as a product that emits radiation in all directions except in the base direction) or directional. Manufacturers shall self-designate the lamp type using the "Lamp Category" field.

- In addition to beam angle, screw-base replacements for HID lamps shall report field angle during the application process. This information will be displayed on the QPL.
- Screw-base replacements for HID lamps shall report intended mounting position. PPID polar plots shall include tested mounting position.

QPL Listing Information: All Replacement Lamps

In addition to existing fields, replacement lamps will have the following information listed on the Horticultural Lighting QPL:

- **"Lamp Category"**
  - Options include: Linear Replacement Lamp; Screw-Base Replacements for HID Lamps - Omni-Directional; or Screw-Base Replacements for HID Lamps – Directional.
- **"Base Type"**
  - Options include: G13, G5, FA8, E39, E40.
- **"Product Size Information"**
  - Linear replacement lamps shall complete the following fields on the application form: "Length (including pin bases)" and "diameter."**Figure 1** shows dimensions of a typical linear replacement lamp that shall be reported on the application form.

- Screw-base replacement lamps shall complete the following fields on the application form: “length,” “width,” “height.” **Figure 2** shows dimensions of a typical screw-base replacement lamp that shall be reported on the application form.
    - Width and height can be the same value if the lamp is round (sometimes referred to as “corn-cob style”).
    - If the lamp is not round (sometimes referred to as “paddle style”), width should be the maximum dimension perpendicular to the screw base.

- **“UL Type”**
    - Options for Linear Replacement Lamps include: UL Type A, UL Type B, Dual Mode (UL Type AB), UL Type C.
    - The only option for screw-base replacements for HID lamps is UL Type B.
- **“Reported Beam Angle”**
- **“Reported Field Angle”** (Screw-Base Replacements for HID Lamps only)
- **“Intended Mounting”** (Screw-Base Replacements for HID Lamps only)
    - Options include: horizontal, vertical, or universal.

Figure 1: Dimensions of linear replacement lamps to be reported on the application form.

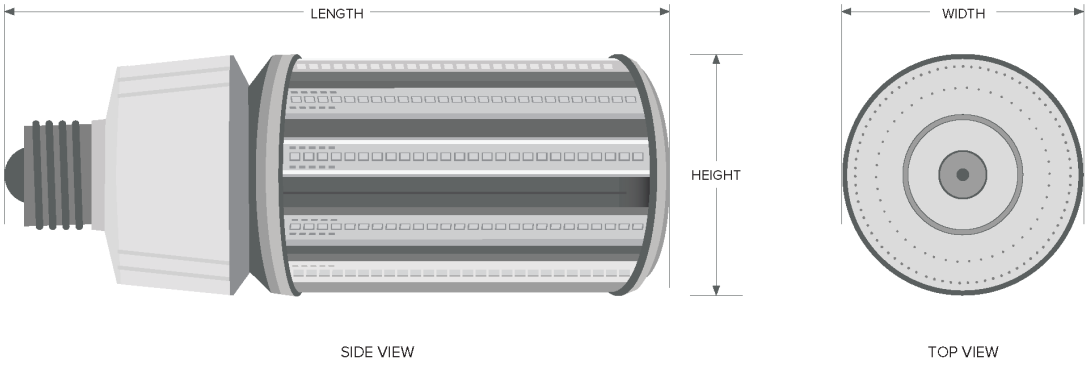

Figure 2: Dimensions of screw-base replacement lamps to be reported on the application form (“corn-cob style” example). If the lamp is not round, width should be the maximum dimension perpendicular to the screw base.

Tolerances

The DLC accepts measurement tolerances to most metrics listed in the Technical Requirements. Please refer to **Table 9** below for additional tolerance information.

Table 9: DLC Horticultural Lighting Technical Requirements Tolerances

Parameter/Attribute/Metric	V3.0 Tolerances
Photosynthetic Photon Efficacy	-5%
Power Factor	-3 percentage points
Total Harmonic Distortion	+5 percentage points
ISTMT Temperature Measurements	1.1°C or 0.4%, whichever is greater
LM-80 Drive Current	-5%

Tolerances are intended to account for all testing variation, rounding, and significant digits. The requirement values and tolerances will be interpreted by DLC review staff as exact requirements. While test labs will be expected to follow the requirements of their accreditation and relevant test standards, DLC staff will not employ additional "rounding" to interpret values below the absolute thresholds as passing. For example, if a horticultural lighting product is required to have a PPE of 2.3 with an efficacy tolerance of -5%, any value for efficacy less than 2.19 will be interpreted as a failing value. It is the applicant's responsibility to check all data presented in an application before submission to ensure compliance with the DLC requirements.

Supporting Documentation

Test Reports

The DLC requires that all testing be conducted at appropriately accredited laboratories except where noted otherwise. Specifically:

- Testing of flux, intensity, and electrical characteristics shall be conducted at laboratories that are accredited to ISO 17025 and the appropriate reference test standard by accreditation bodies that are signatories to the ILAC-MRA.
    - Labs conducting whole-fixture performance testing shall also follow the DLC requirements for LM-79 labs.
- Labs conducting testing of device-level and/or fixture-level photon flux maintenance shall also follow the DLC requirements for LM-80/LM-84 labs.
- Labs conducting *In-Situ Temperature Measurement Testing* (ISTMT) shall meet at least one of the following:
    - Approved by OSHA as Nationally Recognized Testing Laboratories (NRTLs)

- Approved through an OSHA NRTL data acceptance program or OSHA Satellite Notification and Acceptance Program (SNAP)
- Accredited for ANSI/UL 1598 or CSA C22.2 No. 250.0-08, including Sections 19.7, 19.10-16, by an accreditation organization that is an ILAC-MRA Signatory

TM-33-18 Reporting

The DLC requires all applicants to submit accompanying .xml documents per ANSI/IES TM-33-18 for each parent or single product to represent the spatial and spectral distribution of the tested fixture.

- The .xml document shall be based on measured data from an accredited lab, accompanying the LM-79 testing requirements for spectral and spatial measurements.
- The .xml document shall include the spectral power distribution data, with an interval resolution of 5nm or smaller over the photosynthetic and far-red range of wavelengths defined by ANSI/ASABE S640 (400-800nm). The DLC also requires the distribution of photon flux per photon wavelengths over the PBAR range (280-800nm) in the case that applicants provide PF_{PBAR} and PE_{PBAR} data. Spectral data in 1nm intervals are acceptable. The spectral measurement represents the integrated flux in all directions from the fixture, without directional spectral information. Per TM-33-18, the data is reported in W/nm, not spectral quantum distributions. All DLC developed and interim manufacturer submitted SQD images will report in $\mu mol \times s^{-1} \times nm^{-1}$.
- The .xml document shall also include the photosynthetic photon intensity distribution (PPID), reported in $\mu mol \times s^{-1} \times sr^{-1}$, over the photosynthetic wavelengths defined by ANSI/ASABE S640 (400-700nm). PPID is the distribution of photosynthetic photon intensity per unit solid angle leaving the fixture. Each measurement is integrated across the 400-700nm range leaving the fixture and contains no granular spectral distribution information (i.e., color over angle).
- TM-33 documents are separated into six elements: Version, Header, Luminaire, Equipment, Emitter, and Custom Data. In addition to all 'required' elements per TM-33-18, the following describes elements required by DLC for V3.0 compliance.
  - Header Element Required Fields
    - Manufacturer
    - Catalog Number
    - Laboratory
    - Report Number
    - Report Date
  - Luminaire Element Required Fields
    - Dimensions
    - Number of Emitters
  - Emitter Element Required Fields
    - Quantity
    - Description
    - Catalog Number

        - Input Wattage
        - Power Factor
        - Data Generation – Intensity Scaling element field shall be ‘false’. Scaling with respect to laboratory measurements will be not accepted. Angle interpolation element shall be 'true' or 'false', not blank.
        - Photon Data – Photon Intensity data fields shall include ONLY PPF (400-700 nm). Photon Flux data field shall report ONLY PPF (400-700 nm).
        - Spectral Data – Spectral Intensity shall be reported. Additionally, Emitter Name is required for spectrally tunable products.
    - Custom Data Element Required Fields
        - A custom data element called ‘Radiant Power to PPF Scalar Multiplier’ shall be reported for the ratio of PPF to radiant watts within the PAR range (400–700 nm). The ‘Any Data’ field shall describe this scalar multiplier. Unique Identifier data field must contain a Universally Unique Identifier (UUID), as defined by RFC 4122.
- It is acceptable to report element fields described in TM-33-18 that are not detailed above. All data shall be reported to the number of decimal places per the Horticultural Lighting Technical Requirements.

Additional Application Details

In addition to the test data noted in the sections above, the DLC requires the following for all submissions:

- A completed web-based application form.
- Specification sheets (or “cut sheets”) for the product that include maximum ambient temperature.
- Specification sheets for all drivers and fans employed in the product, including lifetime-at-temperature information.
- Safety certificates of compliance as issued by the relevant safety body, attested to by the DLC self-certification statement.
- If demonstrating flux maintenance at the device-level, a completed TM-21 calculator shall be provided for each LED device present in the fixture, with the applicable LM-80 and ISTMT information for that LED device. If demonstrating flux maintenance at the fixture-level, a completed TM-28 calculator shall be provided for the fixture, with the applicable LM-84 information accompanying it.

The DLC will only accept applications for products with testing on the product submitted, with only limited variations permitted as detailed in the sections above. Given the multiple options within product families, the DLC offers the Level 2 (formerly Family Grouping) Application Requirements for LED-based Horticultural Lighting, which describes a method to determine “worst-case” product family members.

Surveillance Testing Draft Policy

Version 3.0 Draft 1 proposes specific surveillance testing requirements to actively monitor the validity of data and other information submitted to the DLC Horticultural Lighting QPL to protect the integrity and value of the QPL for all stakeholders. The draft Horticultural Lighting Surveillance Testing Policy outlines the process for selection of products from the QPL for surveillance testing. The DLC may seek to implement additional efforts toward these objectives in future policy development cycles.

Please review the draft Horticultural Lighting Surveillance Testing Policy and provide any on how the DLC should or should not monitor the validity of QPL listed products.

Download Draft Horticultural Lighting Surveillance Testing Policy