Draft policy for stakeholder comment

Testing and Reporting Requirements for LED-based Horticultural Lighting

Version 2.1 – Draft 2

Proposed Effective Date: July 1, 2021

Text in yellow boxes indicates proposed changes from Version 2.0 that are open for comment.

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 sections 6.8.5 and 10.3.1 or 6.8.5.3 and 6.8.5.4, respectively.

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 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 eligibility rules for horticultural lighting equipment:

- Products that are light engines (analogous to LS-1 section 6.8.5.5) or identified as retrofit kits intended to replace the light sources or other structures within an existing fixture are not eligible for qualification at this time.

- Fixtures that incorporate light sources other than LED, whether as sole-source or as LED-hybrid fixtures, are not eligible for qualification at this time.
- 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 which 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 can be submitted as a single model number, and the multiple options can 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 cannot 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 in the application process discovered outside the application process will generally be considered a violation of the DLC program and trademark rules.
    - Each model number can only represent the fixture under a single brand. If the fixture 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**.

61 **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 (K_p or PPE) ($\mu mol \times J^{-1}$)	≥1.90 $\mu mol \times J^{-1}$	Required/Threshold	(ANSI/IES LM-79) 400-700nm range
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 technical specification sheet, and *In-Situ Temperature Measurement Test* (ISTMT)

Parameter/Attribute/Metric	Requirement	Requirement Type	Method of Measurement/Evaluation
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 technical specification sheet, fixture technical specification sheet, and *In-Situ Temperature Measurement Test* (ISTMT)
Fan Lifetime	≥50,000 hours	Required/Threshold	Fan technical specification sheet, fixture technical specification sheet
Warranty	5 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/Threshold	ANSI/UL 8800 (ANSI/CAN/UL 8800)

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 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 must be measured and reported from an appropriately accredited facility.

  An image of this distribution must 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-33-18 to generate these images in the future.

Please refer to the TM-33-18 Reporting and Photometric/Spectral Reporting Alternatives section for additional information.

- **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-33-18 to generate these images in the future.

  Please refer to the TM-33-18 Reporting and Photometric/Spectral Reporting Alternatives section for additional information.

  Note: The DLC will no longer accept distribution data that are developed through in-house assessments. Products that were qualified prior to the V2.0 effective date must provide TM-33-18 documents by December 31, 2021 to requalify to the V2.0 Technical Requirements, or the products will be delisted.

Efficacy:

The DLC requires testing and reporting of Photosynthetic Photon Efficacy (PPE), which 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 are required to have a PPE of ≥ 1.90 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 1.81 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 1.81 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 must be provided.
- For each unique driver used, manufacturers must 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 must 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 must undergo formal whole-fixture LM-79 testing by an accredited testing lab.
- For questions about testing requirements for family grouping applications, please refer to the Family Grouping Application Requirements for LED-based Horticultural Lighting policy.

- Drivers that result in explicitly different nominal fixture performance (for example, if a driver change 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 family grouping 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 Family Grouping Application Requirements for LED-based Horticultural Lighting policy 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 must 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.
  - 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 must be provided for both the 400-700nm and the 700-800nm range.

- All new product submissions using the LM-80/TM-21 approach are required to 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 qualified with non-PPF units that were converted into PPF units during the provisional period (i.e. prior to V1.2) will be required to provide LM-80 data in appropriate units to requalify under the V2.0 Technical Requirements.
    - Provisionally qualified products will be allowed to update their listings to remove any caveats by submitting actual data by December 2021. The DLC will process these update applications through the month of December, 2021.
- Products may 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 are required to undergo LM-84 testing for TM-28 projections.

- *In-Situ Temperature Measurement Testing (ISTMT):*
    - ISTMTs must be conducted and provided for the hottest LED in the fixture, and LED-device level drive current must be reported.
    - ISTMTs must be conducted and reported in the same manner as thermal testing for safety certification. Specifically, applicants must 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) must 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 must 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 must 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 must 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 must 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 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.

- **Warranty**

  Products must have a manufacturer-provided product warranty of at least five years. The warranty terms and conditions must be provided as part of the submittal for qualification. The warranty must 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 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.

- **Driver ISTMT**

  Applicants must 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 must be conducted, and a report must 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.

  As noted in the ISTMT description within the flux maintenance section, driver ISTMTs must be conducted and reported in the same manner as thermal testing for safety certification. Specifically, applicants must report the operating temperature of the driver 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 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 must be provided with the details above. Testing must 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, then the single worst-case thermal ambient environment of the product line or series requires a driver ISTMT. 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.

- **Fans**

  Products that employ on-board cooling fans must 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 must state the lifetime of the fan and a reference operating temperature rating for that lifetime claim. The lifetime must 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 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.

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 must 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 must 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 must 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 must be documented and included in the application materials. Please see the efficacy section regarding the use of this electrical testing for worst-case efficacy driver variation determination. Please refer to the Family Grouping Testing Requirements for LED-based Horticultural Lighting policy for specific testing and reporting requirements for product families.

Safety:

Products must 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.

For illustrative and reference purposes, practices of acceptable safety organizations are described below:

- **UL**
  Fixture manufacturers who use UL for safety certification purposes are required to be listed on the UL Certification Directory under the designation IFAU.

- **ETL/Intertek**
  Fixture manufacturers who use ETL for safety certification are required to be listed on the ETL Certification Directory, specifically as Horticultural Fixtures.
- **CSA Group**
  Fixture manufacturers who use CSA for safety certification are required to be listed under CSA Group's Classes defined for horticultural lighting equipment in Canada and the US.
- **TÜV SÜD**
  Fixture manufacturers who use TÜV SÜD for safety certification are required to be listed on the TÜV SÜD Certification Directory, specifically as a light fixture for use on horticulture purposes.
- **SGS**
  Fixture manufacturers who use SGS for safety certification are required to be listed on the SGS Certification Directory, specifically as horticultural lighting equipment.
- **Other safety organizations**
  To be added to the DLC's approved list of safety organizations who certify horticultural lighting equipment per ANSI/CAN/UL 8800 requirements, please contact horticulture@designlights.org.

Special Considerations

Special Considerations for Spectrally-Tunable Products

Spectrally-tunable products (those 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 must 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 must 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 must perform PPF testing for each control channel, in which the channel under test must be set to the maximum designed output, while all other channels must be set to their minimum designed output for this state. The test report must 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 must 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 must provide user-facing documentation narrating the control protocol and input parameters employed in controlling the output.
- For PFM_P and PFM_{FR} evaluation:
    - Provisions for products utilizing multiple types of LEDs must be followed as described in the For fixtures using multiple types of LEDs section.
    - ISTMT testing must be provided on the hottest of each of the LED types. For each unique LED type, ISTMT testing must occur at the operating mode that produces the highest operating temperature in the fixture, for this LED type.
    - 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.

PROPOSED 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 fixtures where one or several AC-to-DC power source(s) supply(s) power to multiple fixtures.** 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 Information

All V2 Horticultural Lighting Technical Requirements described in **Table 1** must 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 must 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. For dimmable or tunable products, this is the test report of the product at its maximum (non-dimmed) power state.
- **Tested Power Source Report**: If power sources are marketed with the DC-powered fixture, applicants must provide a table of the following performance values for all drivers 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 must be provided at the minimum and maximum AC input voltages for each driver, 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 must be provided at each of three load points as determined by the fixture manufacturer (or two load points for power sources that are specified as not allowing loading below 50%):
  - Maximum rated power load
  - 50% of maximum load
  - 20% of maximum load, or the minimum loading specified on the fixture specification sheet if that loading is between 20% and 50%.
  - If the fixture specification sheet specifies minimum loading above 50%, performance values must be provided at full power and at that minimum loading percentage. For example, the minimum load may be specified by minimum requirements such as:
    - One fixture on a given power source: “30% load for a 100W power source that may power one to three 30W fixtures,”
    - A minimum number of fixtures per power source specified on the fixture specification sheet: “60% load for a 100W power source that may power either two or three 30W fixtures,” or
    - A loading requirement for a given power source listed on the fixture specification sheet: “Required operating range of 15-90W output at 100W input power.”
- Performance values to be reported in the benchtop test report:
  - Input power demand, shown to the nearest hundredth of a watt
  - DC output power demand, shown to the nearest hundredth of a watt
  - Electrical efficiency (driver output power demand divided by driver power demand), 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 with one decimal place

- The following example shows this table for a single power supply:

Manufacturer Name		Model Number		AC Input Voltage Range (V)		DC Output Voltage Range (V)	
ABC Corp.		*ABC123*		*120-277*		*48*	
Input Voltage (V)	**Output Power Range (W)**	**Loading Percentage (%)**	**Tested Input Power (W)**	**Tested Output Power (W)**	**Tested Efficiency (%)**	**Power Factor**	**Total Harmonic Distortion (current) (%)**
120	300-3000	**100**	3115.2	3000.0	96.30	0.932	5.0
		50	1610.1	1500.1	93.17	0.928	4.1
		20	677.6	600.0	88.55	0.914	4.0
		Mfgr Minimum	N/A	N/A	N/A	N/A	N/A
277	300-3000	**100**	3098	3000.0	96.84	0.932	5.6
		50	1600.8	1500.1	93.71	0.927	5.7
		20	665.1	600.0	90.21	0.911	5.9
		Mfgr Minimum	N/A	N/A	N/A	N/A	N/A

  - Fixtures that are not offered for sale with any AC-to-DC power source are not required to provide a tested driver report. These products will be listed with an assumed AC-to-DC conversion efficiency—see below.

- Consistent with the Horticultural Technical Requirements, Driver ISTMT Reports are required for all horticultural products sold with AC-to-DC or DC-to-DC power sources.
  - Fixtures that are not offered for sale with an AC-to-DC power source are not required to provide a Driver ISTMT Report.
- 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.

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:

- New fields will be reported:
  - **"System Type"** will be distinguished between AC and DC products.
  - **"DC Input Voltage"** and **"DC Input Current"**, from DC-powered LM-79 for both DC-powered fixture types.
  - "**DC Input Power"** and **"DC Photosynthetic Photon Efficacy: 400-700 nm, µmol/J (DC PPE)"** will display the values from the all-on DC photon flux report.
    - Optional new field **"DC PE_{PBAR}"** will be reported if PE_{PBAR} is reported.
  - New fields will display **"AC De-rated Input Power"** and **"AC De-rated PPE"** only for DC-powered fixtures.
    - Additionally, 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 2.5 and a power supply showing a worst-case efficiency of 85% at 20% load, would be listed on the QPL at 2.13 µmol/J and 118W.

- Additionally, 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 per 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}"** will be reported if PE_{PBAR} is reported.
- **"Power Source Loading Percentage"** will display loading that creates the worst-case efficiency used in the de-rating calculations.

- Additionally, a new field showing an example of **"Cabling length and gauge that results in cabling losses less than 2% for a fully-loaded power supply"** will be displayed.
  - For example: "Nine 300W fixtures parallel-wired with 100 feet of 10AWG cabling to a 3,000W power supply channel."
  - The fixture wattage must match the input power of the submitted fixture, and the cabling losses must reflect the copper resistance values listed in NFPA 70. 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.
  - This field will not be populated for DC-powered fixtures that are not marketed with any AC-to-DC power source.

- The fields currently used for **"Photosynthetic Photon Efficacy: 400-700 nm, µmol/J (PPE) (AC)"** will not be populated.
- 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**." THD and power factor fields will not be populated for fixtures that are not marketed with any AC-to-DC power source.

Key Questions for V2.1 Draft 2, DC-Powered Fixtures

1. Draft 2 specifies that the AC de-rated fields for DC-powered fixtures (**PPE**, **Input Power**, and optionally **PE_{PBAR}**) will be listed on the QPL, including the power source loading percentage that creates the worst-case condition. Should any other information about that worst-case performance scenario be included? For example: the rated output power of the power source? Or the worst-case power source efficiency?
2. Draft 2 no longer requires that longest-allowable cabling losses be included in the LM-79 performance testing. A new field added to the listing requirements for DC-powered fixtures will offer an example of the **"cabling length and gauge that results in cabling losses below 2% for a**

fully-loaded power supply." Is this cabling example useful in a listing for QPL users? Is there a better listing field to demonstrate to QPL users the differences among fixtures in possible cabling, DC voltage, DC current, and parallel or series wiring? Should there be any requirements for cabling examples in product literature?

3. In response to industry outreach, the DLC has proposed that cabling information be reported to maintain cabling to less than 2%. Does this reflect industry best practices? If not, to what percentage should cabling losses be maintained?
4. Is the proposed method for listing de-rated values for fixtures not offered for sale with any power source appropriate?
5. Is it beneficial to list de-rated AC values for Input Power and PPE, in addition to DC values? Are AC values for a worst-case configuration useful in evaluating proposed horticultural lighting systems? Or are system evaluators, such as custom incentive program engineers, more likely to use manufacturer-provided information to calculate power and PPE at the actual load conditions, driver configuration, and input voltage of the system under consideration?
6. Are the performance data values required for the power source table available from power source manufacturers?
7. The proposed requirements would offer no information on power source efficiency below 20% load condition. Is it important to capture power source efficiency below 20% loading, and if so where does this load condition exist in horticultural lighting applications? What minimum loading percentage would reflect this real-world use for AC-de-rated reporting?

PROPOSED 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. LED horticultural fixtures that employ externally supplied ducted forced air are not eligible at this time. For simplicity, Version 2.1 may refer to eligible externally supplied actively cooled fixtures as 'actively cooled'.
- 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.

Technical Requirements Information

- All V2 Horticultural Lighting Technical Requirements described in **Table 1** must be met in addition to the following requirements and clarifications:
    - Manufacturers must 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 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 reported on the Hort QPL.
            - An image describing the graphical relationship between PPE and inlet fluid temperature covering the complete allowable inlet fluid temperature range shall be provided and reported on the Hort QPL.
                - Flow rate must be held constant across the temperature range and reported on the provided graph.
                - At a minimum, this image shall relate inlet fluid temperature (x-axis) to fixture PPE (y-axis) and must be submitted within the application in a .jpg graphical file format, at a size of 500x500 pixels or larger. This image will be posted on the Hort QPL.
            - All inlet fluid temperature values shall be reported in degrees Celsius.
        - **Self-Protect Cut-Off Functionality:**

- This is the maximum inlet fluid temperature reached before actively cooled luminaires turn off to protect themselves from failure, in the event that the external cooling system fails.
- Self-protect cutoff temperature must be stated in manufacturer provided marketing material/specification sheet and shall be reported on the Hort QPL.

- LM-79 testing must employ water as the cooling liquid at an appropriate flow rate to maintain the targeted *median inlet fluid temperature* (i.e. middle allowable operating inlet fluid temperature) as defined by the luminaire manufacturer. Average and highest inlet fluid temperature measured during LM-79 testing (measured at fixture-level stabilization per LM-79) shall be provided and reported on the Hort QPL.
- ISTMT testing must employ water as the cooling liquid at an appropriate flow rate to maintain the targeted *worst-case inlet fluid temperature* (i.e. hottest allowable operating inlet fluid temperature) as defined by the luminaire manufacturer. Average and highest inlet fluid temperature measured during ISTMT testing (at stabilization) shall be provided and reported on the Hort QPL.
    - ISTMT reports must report temperature(s) at the fixture's highest rated ambient temperature, when the highest-rated ambient temperature is greater than the ISTMT ambient temperature.
- All inlet fluid temperatures must be maintained within a tolerance of +/- 2.5 degrees to the target temperature during LM-79 and ISTMT testing.
- Flow rate in terms of gallons per minute (GPM) must be measured during LM-79 testing, with the average and highest flow rate measurements being provided and reported on the Hort QPL.
- Outlet fluid temperature must 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 from Type C goniometers and other gonioradiometer types.
    - All *externally* supplied circulating liquid cooled horticultural fixtures seeking qualification by the DLC must test the fixture per ANSI/IES LM-79, including requirements specific to, but not limited to, stabilization and optical measurements, while employing active cooling.

QPL Listing Information

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

- **"System Type"**
    - *Externally* supplied circulating liquid cooled horticultural fixtures will be distinguished as an AC or DC product, as appropriate, and active cooling presence 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
- 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"**
    - **PPE vs. Allowable Inlet Fluid Temperature image**

Key Questions for V2.1 Draft 2, Externally Supplied Actively Cooled Fixtures

1. The DLC has proposed that *externally* supplied circulating liquid horticultural fixtures maintain with +/-2.5 degrees C tolerance of the targeted (median or worst-case) inlet fluid temperature. Do LM-79 accredited NRTLs have any concerns with maintaining inlet fluid temperatures within +/-2.5 degrees C? If so, what tolerance would better align with industry best practices?
2. The DLC has proposed to collect and report an image that displays luminaire-level PPE as a function of inlet fluid temperature to inform our stakeholders about the potential impact the external cooling system design can have on luminaire-level efficacy. Is an image the preferred way for reporting this information on the Hort QPL? If not, what format would be more useful to QPL users?
3. To support testing of actively cooled products while employing the cooling system, the DLC has proposed to allow LM-79 testing with other than Type C gonioradiometers, which is in conflict with LM-79 requirements which require Type C gonioradiometers . What concerns, if any, are there for NRTLs testing to LM-79 requirements with non-Type C gonioradiometers for actively cooled products?
4. What, if any, additional considerations should be made for listing eligibility of *externally* supplied circulating liquid cooled horticultural fixtures?

PROPOSED 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 following linear lamp 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.
    - **Replacement Lamps (UL Type A):**
        - Products in this primary use designation 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 mechanical or electrical changes to the fixture.
    - **Internal Driver/Line Voltage Lamp-Style Retrofit Kits (UL Type B):**

        - Products in this category 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 in this category operate utilizing the existing fluorescent ballast and also have the ability to operate utilizing line voltage if the fixture is rewired to bypass the ballast. These products connect to the fixture using standard pin-base connections to the lamp holders.
    - **External Driver Lamp-Style Retrofit Kits (UL Type C):**
        - Products in this category employ lamp holders to connect to the fixture being retrofitted, do not operate utilizing the existing fluorescent ballast, and require rewiring of the existing fixture to replace the ballast with an external driver (e.g. the driver is internal to the fixture but external to the lamp). The lamp holders are then wired to receive only the low-voltage electricity that is supplied by that driver.
        - For Type-C lamp systems with non-identical lamps, *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 apply.
- 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.

Technical Requirements Information: Linear Replacement Lamps

- Linear replacement lamps seeking horticultural lighting qualification must test the bare lamp according to LM-79 to meet all V2 Horticultural Lighting Technical Requirements as described in **Table 1**, except for Driver Lifetime:
    - Instead of Driver Lifetime:
        - Lamps must perform In-Situ Temperature Measurement Test (ISTMT) and report at the product's highest rated ambient temperature using a location on the lamp housing, designated by its manufacturer, which will have the highest temperature of any point on the lamp during normal operation.
        - Applicants must 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) for monitoring the operating temperature.
        - In-situ temperature measurement testing must be conducted, and a report must be provided with the application showing an operating temperature

consistent with the specification sheet information and 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.

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. 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 are not eligible at this time.

Technical Requirements Information: Screw-Base Replacements for HID Lamps

- Screw-base replacements for HID lamps seeking horticultural lighting qualification must test the bare lamp according to LM-79 to meet all V2 Horticultural Lighting Technical Requirements as described in **Table 1**, except for Driver Lifetime, as with Linear Replacement Lamps (see above).
- 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 must self-designate the lamp type using the "Lamp Category" field.
    - Screw-base replacements for HID lamps must report beam angle and field angle during the application process. This information will be displayed on the QPL.
- Screw-base replacements for HID lamps must report intended mounting position. PPID polar plots must 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 must include the nominal length in inches

    - Screw-base replacements for HID lamps must include product dimensions as Maximum Overall Length (including base) x width/diameter x height
- **"UL Type"**
    - Options for Linear Replacement Lamps include: UL Type A, UL Type B, Dual Mode (UL Type AB), UL Type C
    - Options for Screw-base replacements for HID lamps include: UL Type B
- **"Beam Angle"**
- **"Field Angle"** (Screw-Base Replacements for HID Lamps only)
- **"Intended Mounting"** (Screw-Base Replacements for HID Lamps only)
    - Options include: horizontal, vertical, or universal

Key Questions for V2.1 Draft 2, LED Replacement Lamps

1. In stakeholder comments on Draft 1, the DLC heard that lamps cannot meet the driver lifetime requirements in Table 1 because circuitry for most lamps is often integrated into the electronics of the lamp, therefore there is not a single element to make the claim nor perform the testing/documentation. As such, in Draft 2 lamps are exempt from meeting the driver lifetime requirements but must still have a product lifetime of at least 50,000 hours and perform ISTMT at a manufacturer designated location. **Is this lifetime requirement reasonable? If not, please provide justification to support your rationale.**
2. In stakeholder comments on Draft 1, the DLC heard that lamps may have difficulty meeting the Photon Flux Maintenance requirement of Q90 ≥36,000 hours and/or the warranty requirement of 5 years. **If these requirements are not reasonable for lamps, please provide a recommendation of reasonable requirements and justification to support your rationale.**

Tolerances

The DLC accepts measurement tolerances to most metrics listed in the Technical Requirements. Please refer to **Table 2** below for additional tolerance information.

Table 2: DLC Horticultural Lighting Technical Requirements Tolerances

Parameter/Attribute/Metric	V2.0 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 1.9 with an efficacy tolerance of -5%, any value for efficacy less than 1.81 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 must 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 must also follow the DLC requirements for LM-79 labs.

- Labs conducting testing of device-level and/or fixture-level photon flux maintenance must also follow the DLC requirements for LM-80/LM-84 labs.
- Labs conducting *In-Situ Temperature Measurement Testing* (ISTMT) must 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 and Photometric/Spectral Reporting Alternatives

The DLC requires all applicants to submit accompanying .xml files 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 file must be based on measured data from an accredited lab, accompanying the LM-79 testing requirements for spectral and spatial measurements.
- The .xml file must 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 file must 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).

To facilitate time for accredited labs to develop or purchase TM-33-18 reporting software, the DLC offers a 9-month grace period for applicants to provide .xml files compliant with TM-33 reporting for parent products. If TM-33-18 reports are not available, applicants must submit LM-63 and TM-27 (i.e. .ies and .spdx files, respectively) for parent products or single products.

- For manufacturers choosing to submit .ies and .spdx files instead of .xml files in the interim period, they must resubmit data compliant with TM-33-18 reporting requirements by December 31, 2021, or the products will be delisted.

- The .ies files must contain [_OTHER] keywords to describe the units of intensity values and a conversion factor relating photosynthetic photon intensity to luminous intensity (conversion factor = PPF/lumens).

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 must 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 must 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 Family Grouping Application Requirements for LED-based Horticultural Lighting policy, which describes a method to determine "worst-case" product family members.