Testing and Reporting Requirements for Color-Tunable Products

Color-Tunable products must comply with the provisions of this document to be eligible for listing on the DLC Solid-State Lighting Qualified Products List (SSL QPL). Color-Tunable products are defined as products whose Correlated Color Temperature (CCT) can be adjusted via an input control of any type and whose chromaticity approximately follows the blackbody locus, providing white light at all input configurations. For this purpose, white light is defined as chromaticity coordinates within the twenty, 7-step quadrangles of ANSI C78.377-2017 Basic and Extended Specifications. Products supplying colored light (i.e. those capable of generating color points with Duv magnitudes beyond the limits of the ANSI Extended specification, also known as Full Color-Tunable) are outside the scope of these proposed requirements and ineligible for listing at this time. White-Tunable products must utilize a control interface or multiple interface options clearly described in the product literature that allow for at least two CCT settings. These may be continuously-variable inputs such as a 0-10V DC signal, an established protocol such as DALI or DMX, a proprietary control signal, setting options described in terms of CCT such as 3000K or 5000K, or simple descriptive terms such as 'Night' or 'Day'.

Type Definitions of Color-Tunable Products

Two types of Products are eligible for listing as Color-Tunable:

1. **White-Tunable products**, have a control signal specifically for adjusting CCT while maintaining nominally constant lumen output. These products may include a second, independent dimming control. White-Tunable products include both “white-white” products that combine the output of 2 LED primaries, and products with 3 or more white and/or RGB LED primaries, so long as they only produce white light as characterized above in response to their control signal.
    a. NOTE: In order for a white-tunable product, standard or premium, to exhibit constant lumen output, the light output must not vary more than 20% between any CCT measurement across the full

range of the CCT adjustment control signal. This will be verified by testing at the minimum, maximum, and intermediate CCT control input, as well as the reported lumen output values for each ANSI CCT Quadrangle during the application submission process. Products where the light output varies by more than 20% between CCT measurements (excluding light output changes resulting from a separate dimming control signal) are not eligible at this time.

2. **Warm-Dimming products** have a single input which controls both color temperature and lumen output, lowering the values of both concurrently, most typically to mimic the color temperature shift of incandescent dimming. Products that require on an external control system to coordinate dimming and warming color temperature are not eligible.

To be eligible for QPL listing, Color-Tunable products must meet either White-Tunable or Warm-Dimming requirements.

White-Tunable Eligibility

The following are eligibility rules for White-Tunable products:

- White tunable products are not eligible to be submitted as single product applications. Both single products and product families must submit a Family Grouping Application and meet all the Family Grouping eligibility requirements. For the purposes of color tuning eligibility, the DLC's existing requirements that a family must contain a "standardized set of LED packages/modules/arrays" and must demonstrate scalability or modularity using "any other applicable features" apply also to White-Tunable families, in that they must have identical chipsets and modular groupings of chipsets, resulting in an identical technological approach to color output.
- White-Tunable products must meet the DLC Technical Requirements at all values of the color control signal for the General Application(s) and Primary Use(s) for which they are submitted, except for CCT. This includes minimum light output, efficacy, CRI, lumen maintenance, THD, Power Factor, and zonal distribution/spacing criteria requirements.
- White-Tunable products must be capable of producing light at CCTs in alignment with existing maximum CCT limits for DLC qualified products (≤ 5700K for Outdoor or High-Bay products and CCTs ≤ 5000K for other Interior products). However, no maximum or minimum CCT range is required for color tuning eligibility in general. Standard DLC metric allowances apply as outlined in Table 6.

- White-Tunable products will only be classified as DLC Premium if they meet all DLC Premium classification (again, except CCT) requirements at all values of the color control settings. Additional documentation may be required.
- White-Tunable products may also have field-adjustable lumen output characteristics, in which case they are also subject to the Field-Adjustable Products Testing and Reporting Requirements. If products exhibit both performance features, they must comply with both White-Tunable and Field-Adjustable Products Testing and Reporting Requirements.

White-Tunable Testing

The testing for White-Tunable products must be provided to cover all areas of investigation as with non-color tuning family groups, plus additional testing across the color-tunable range for the least efficacious product.

White-Tunable product family submittals must include all testing reports required in this section. For White-Tunable products that also have an independent dimming control, testing must be conducted at the highest lumen output setting available for that CCT. For White-Tunable products with multiple control protocol options, testing must be conducted based on the most consumptive driver. For cases where provided test results do not appear to reflect the worst-case or setting required by this document, the DLC will require manufacturers to submit additional information and provide technical rationale to the DLC reviewer to support their case.

Based on consideration of the entire color input signal range for all members of the product family, the product family member with the lowest efficacy of any product-and-color-control-setting combination in the group shall be LM-79 tested for all metrics other than distribution (IES files) at the following test points:

1. The **minimum CCT input control** setting
2. The **maximum CCT input control** setting
3. One **intermediate point**:
    a. For products with continuously variable input signals and those with input signals offering an odd number of discrete settings, the mid-point between the minimum and maximum CCT input signals or the middle setting
    b. For input signals with an even number of discrete settings, the lower of the two middle CCT input settings
4. Where none of the above tests result in the lowest efficacy condition, the **least efficacious** setting

If none of these test points represent 1) the minimum lumen output product-color-control-setting combination, 2) the minimum nominal CCT output, 3) the maximum nominal CCT output, 4) the minimum CRI, 5) the highest power consumption and 6) the worst power quality, then additional LM-79 testing shall be performed for whichever product-and-color-control setting combination within the group performs at the worst-case family-wide for:

5. Photometric distribution testing (goniophotometric testing) for a representative product for each optical variation within the group. This data

must be submitted in IES file format and may be represented additionally in a PDF test report.

6. A test of the product at the color control setting that produces the lowest lumen output within the group
    a. For clarity, dimmable products shall NOT be tested in dimmed states. This is a required test of the product that produces the lowest lumen output of any product at any color control setting, at the maximum output dimming control setting
7. Where the minimum CCT is at least 100K less than the CCT produced at the minimum CCT input control setting, a test of a product at the **minimum CCT**
8. Where the maximum CCT is at least 200K greater than the CCT produced at the maximum CCT input control setting, a test of a product at the **maximum CCT**
9. A test of a product at the **minimum CRI**
10. A test of the product at the highest power consumption setting
11. Where none of the above tests result in the worst-case Power Quality applicant shall submit bench data documenting with the worst Power Quality (Power Factor and THDi)

In-Situ Temperature Measurement Tests (ISTMTs) must be provided on the following:

- Each LED package/module/array (i.e. each component for which LM-80 testing must be provided) at the worst-case thermal condition (worst-case product-setting combination) for that LED
    - It is expected that the worst-case condition for each LED type within a Color-Tunable product will necessarily be under different conditions. If LEDs are employed that have different LM-80s, multiple LED ISTMTs will be required.
- Each driver present in the product, at the worst-case thermal condition for that driver. (For products seeking premium qualification only.)
    - Again, if multiple drivers are used, this may result in the need for multiple driver ISTMTs, under different conditions.

LM-80 testing must be provided for each LED type present in the product. TM-21 projections must be provided for all LEDs at their measured ISTMTs.

- LM-80 applicability will be determined per the ENERGY STAR guidance, as per normal policies.

As part of the application submittal, manufacturers must report the power consumption for each ANSI C78.377-2017 CCT quadrangle from the minimum CCT to the maximum CCT, and for one reported CCT that falls between the quadrangle upper and lower limits. If discrete input control settings do not allow the product to provide light within the CCT range of a particular bin, manufacturers must provide the CCT and power consumption of the closest CCT to that range. If input control settings allow for more than one setting within an ANSI quadrangle, only the data for the setting that produces the actual CCT closest to the nominal CCT center point for the bin per the ANSI standard shall be provided. The data should be provided in the format of Table 1. The DLC will accept the following sources for self-reported/rated performance data.

1. **In-house laboratory test**: In-house test reports from tests conducted in accordance with IESNA LM-79
2. **Calculated Scaling:** Provide mathematical characterization of luminaire performance based on manufacturer-developed scaling methodology. The manufacturer must provide a description of the scaling methodology employed and the technical basis for its validity. The DLC reserves the right to accept or reject the methodology for use in qualifying products.

Table 1: Data reporting format for white-tunable product submissions

ANSI CCT Quadrangle (omit any outside product range) / Worst-Case Value	Actual CCT (K)	Power Consumption (W)	Lumen Output (lm)	Input Control Signal Applied
2200 K				
2500 K				
2700 K				
3000 K				
3500 K				
4000 K				
4500 K				
5000 K				
5700 K				
6500 K				
Lowest Efficacy				
Maximum Power				

Manufacturers can provide in-house testing on driver characteristics and zonal lumen output or other testing that might be necessary to support the designation of a least-efficacious or highest-power-consumption control setting. As per normal, in-house testing informs selection of worst-case. Actual worst-case testing must be conducted per the appropriate test standard at an accredited lab.

Guidance for "Input Control Signal Applied" Field in Table 1

Applicants should use the following guidance when completing the “Input Control Signal Applied” field for Color Tunable Products. The values shown should be specific to how the luminaire responds to the control signal, not varying for a single luminaire depending on the control hardware or software used.

1. 0 – 10V control systems should provide an actual DC voltage value, shown to the tenth of a volt.
2. DALI color control using DALI 209 should provide a value from 0 to 254. Other DALI color control schemes not based around values from 0 to 254 should follow the guidelines for proprietary signals below.
3. All other control protocols for color tuning, including those that use proprietary control signals, should provide a percentage value from 0% to 100%. The percentage, from 0 to 100, should represent control signal applied from lowest CCT to highest CCT, rounded to the nearest percentage. Please note this percent should not be the % of CCT range from lowest CCT to highest CCT; rather, it should reflect the control signal applied. DLC is not looking for values that simply show that 3500K is numerically 25% of the way from 3000K to 5000K but wants to document how manufacturers have chosen to translate the CCT range.
4. The values shown should encompass the full CCT range of the product. If the maximum CCT or minimum CCT point varies for a given product depending on the control signal used, values provided in the table should include the highest maximum CCT and the lowest minimum CCT, even if different control signals are required to achieve the two.

Warm-Dimming Eligibility

The following are eligibility rules for Warm-Dimming products:

- Warm-Dimming products must meet all DLC Technical Requirements, including CCT, for the General Application(s) and Primary Use(s) for which they are submitted, as measured at the maximum output for the product. The requirements include minimum lumen output, efficacy, CRI, CCT, lumen maintenance, THD, Power Factor, and zonal distribution/spacing criteria requirements. Standard DLC metric allowances apply as outlined in Table 6.

- Warm-Dimming products do not need to meet DLC Technical Requirements at other input control settings, i.e. when they are dimmed below full output.
- Warm-Dimming products will only be classified as DLC Premium if they meet all DLC Premium classification requirements at the maximum input control setting.
- Warm-Dimming products may also have field-adjustable lumen output under the Field-Adjustable Product Testing and Reporting Requirements, and thus be listed under both. If products exhibit both performance features, they must comply with both sets of requirements.

Warm-Dimming Testing

Warm-Dimming product submittals must include a single LM-79 report performed at the **maximum setting of the dimming input control**. If the LM-79 results fail to meet the Technical Requirements, the product will not qualify.

Other testing reports are required as per existing DLC policies for lumen maintenance and in-situ temperature measurement.

Manufacturers can provide in-house testing on driver characteristics and zonal lumen output or other testing that might be necessary to support the designation of a least-efficacious or highest-power-consumption control setting.

The Family Grouping Testing Requirements apply to Warm-Dimming products in the same manner as with non-color tuning products.

Supporting Documentation

Control Interface Documentation:

Applicants shall provide the following supporting documentation with the application submittal. If any of the following information is not clearly documented in the product specification sheet or other supporting technical or marketing materials, the application will be considered incomplete and the DLC reviewer will request additional information.

- Description of the method of the input control, show photos of control input location and control input mechanism
- Reference to any control standards or protocols utilized
- Clear instructions for how to achieve the settings required in the testing section. Identical instructions must be provided to the test laboratory for testing and to the DLC during the application review.

Listing on the QPL

Products will be identifiable on the QPL with either “White-Tunable” or “Warm-Dimming” values under a “Color Tuning” field.

White-Tunable products will be listed on the QPL at the least efficacious setting, with the corresponding product performance characteristics from that LM-79 test: Light Output, Power Consumption, Efficacy, THD, Power Factor, CRI, CCT, Zonal Lumens, Spacing Criteria. In addition, the QPL will display the Maximum Wattage, Minimum CCT, Maximum CCT, Minimum Light Output, and Maximum Light Output as separate fields.

Warm-Dimming products will be listed on the QPL at the full output setting, with the product performance characteristics from that LM-79 test: Lumen Output, Power Consumption, Efficacy, THD, Power Factor, CRI, Maximum CCT, Minimum CCT, Zonal Lumens, Spacing Criteria. Warm-Dimming products will be listed with only the CCT value corresponding to the full output setting.