

Powertech Labs / BC Hydro Decorative LED Light String Test Protocol Draft Draft Version 1.1

I. Objective

This test protocol is intended to define a test procedure that will be applied to decorative light strings as part of the evaluation process to determine eligibility for the ENERGY STAR Program. Tentative acceptance criteria follow in Section IV.

II. Performance Issues

The following issues have been recognized as critical to customer safety, ENERGY STAR needs, or long term customer acceptance.

- Power consumption
- Current harmonic content
- Apparent brightness and viewing angle
- Lifetime and reliability

Other issues may be added, as they arise.

III. Tests Performed

The following tests may be performed on decorative light strings submitted for evaluation:

1. Initial inspection

- a. Inspect for safety or shock hazard concerns
- b. Count bulbs per string and separation
- c. Check bulb type: sealed, polarized plug-in, or unpolarized plug-in
- d. Check that plug-in diodes, resistors, etc. cannot be incorrectly swapped with spare bulbs
- e. Determine electrical connection scheme (series, series/parallel, etc)
- f. Measure power consumption and current
- g. Measure current waveform and harmonic content

2. Brightness test

A photometric system (described in the appendix) will be used to measure the brightness of three individual bulbs from each test string (or one bulb of each colour in multicoloured strings).

- a. The intensity will also be measured at two points each 30 degrees from the maximum intensity.
- b. If a diffuser can be removed without causing so much damage that the string or bulb is extinguished, test a will be repeated with a bulb with the diffuser removed.

3. Overvoltage test

Strings will be energized at 132 V for 1 hour and examined for failure.

4. Temperature cycling test

Test strings will be subjected to 3 temperature cycles of cooling to -15°C ($\pm 5^{\circ}\text{C}$) for 8 hours and then warming to 20°C ($\pm 5^{\circ}\text{C}$) for 16 hours.

5. Water ingress test

After completing temperature cycling, one sample of each type was tested for water ingress. The low voltage dc resistance was measured at the plug. The uncharged string was then immersed in a salt-water solution at room temperature for 24 hours (the end fittings were kept out of the solution). At the end of the immersion period, the low voltage dc resistance was measured again to check for water ingress.

6. Corrosion resistance test

To be developed.

7. Lamp lifetime test

One sample of each type will be mounted in an oven maintained at 50°C and energized for 1000 hours. The strings will be examined every week (168 hours) to see if they are still illuminated. Note that this test is not a simulation of actual operation, but an accelerated aging test to try to identify substandard diodes. Note: Please comment on the appropriateness of the 50°C oven temperature.

IV. Tentative Acceptance Criteria

The following criteria are under consideration. The criteria will change as new information becomes available, including test results from current decorative light products. Until firm criteria are adopted, product support will depend on an engineering analysis of each product based on the test results and manufacturer's information provided.

1. Initial inspection

- a. There must be no obvious safety or shock hazards.
- b. If the string has plug-in bulbs, they must be polarized and keyed so that incompatible components cannot be exchanged and diodes cannot be reverse biased.
- c. If two series strings are in parallel, they must have opposite polarity to minimize harmonic distortion.
- d. Single strings must be designed so that if multiple strings are connected, approximately half will be of each polarity.

2. Brightness test

To be determined.

3. Overvoltage test

Strings will survive without damage.

4. Temperature cycling test

Strings will survive without damage.

5. Water ingress test

The final resistance value will be greater than a threshold (to be determined), indicating no water ingress has occurred.

6. Corrosion resistance test

To be determined.

7. Lamp lifetime test

To be determined.

Appendix: Photometric system specifications

The photometric system is intended to provide reasonably accurate measurements ($\pm 5\%$) of luminous intensity with sufficient angular resolution to identify potentially hazardous bright spots, at a reasonable cost.

The test chamber will include a mounting head with provision for holding individual bulbs of various designs firmly in position while still connected to the remainder of the light string. The mounting head will have fine adjustments with approximately 0.5 degree resolution in azimuth and elevation angle so that the bulb can be aligned for maximum intensity. The head will also have a coarse adjustment so that it can be rotated in 30 degree steps for the off-axis measurements.

The head will be mounted in a non-reflective, baffled measurement chamber with a calibrated illuminance meter fixed in direct line of sight, 50 ± 1 cm from the bulb base. The aperture of the illuminance meter will be approximately 1 cm, providing a resolution of approximately 1 degree. At 0.5 m distance, the bulb output in candela at any given angle will be $\frac{1}{4}$ of the illuminance meter reading in lux.

The illuminance meter will have an accuracy of 5% or better, and will be calibrated for the standard CIE photopic response curve. Background and reflected light levels will be kept to less than 5% of the normal measurement level through the use of suitable baffles and non-reflective coatings. The centre of rotation for the coarse angle adjustment will be aligned with the base of the bulb. The coarse angle adjustment will be checked geometrically, and the steps will be 30 ± 1 degrees.

Note: During the stakeholder meeting on March 6th, it is planned that the group will spend time discussing the need for a light output test. If it is deemed necessary, the group will discuss the most effective method to test light output. This section has been inserted as a placeholder until that decision is made (See Attachment 1).