



**ENERGY STAR® Program Requirements for
Decorative Light Strings**

Test Procedure and Eligibility Criteria

Version 1.4

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Table of Contents

Section 1 Definitions	2
Section 2 Reference Standards	3
Section 3 Qualifying Products	3
Section 4 Testing and Energy-Efficiency Specifications for Qualifying Products	4
A. Inspection	4
B. Electrical Requirements	5
C. Lifetime Requirements	5
D. Weathering Requirements	6
E. Product Packaging for Consumer Awareness Requirements	6
Section 5 Qualification Process	7
Section 6 Private Labeling Products	8
Section 7 Effective Date	9
Section 8 Future Specification Revisions	9
Appendices	10



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Version 1.4

This document describes the test procedure and eligibility criteria that candidate decorative light strings must undergo to determine eligibility for ENERGY STAR® certification. A light string must meet all of the identified criteria if it is to earn the ENERGY STAR.

This document includes tests that assess both the energy-efficiency and quality of decorative light strings, and is comprised of the following:

- Inspection Test,
- Electrical Test,
- Lifetime Test, and
- Weathering Test.

1) Definitions:

- A. Decorative Light String (DLS) – A string of lamps that operate on AC power in North America (120 V RMS AC, 60 Hz) or via a power adapter or controller that connects directly to AC power, and is used for decorative residential lighting purposes. The lamps may be replaceable or sealed into the lamp holder/wiring harness, and may be assembled in a net or icicle configuration.
- B. Failed Lamp - A lamp has failed if the light output is less than half the expected output for a comparable lamp of the same age in good condition. This will normally be determined by comparison with a good lamp of the same color on the same string.
- C. Input Power - The average total power used by the decorative string during operation, measured in watts, including (if any) the transformer, adapter, controller, etc. For decorative light strings that operate with power adapters that can accommodate more than one string, the input power is defined as the average total power consumed with the rated maximum number of strings attached.

- D. Maintained Light Output – The average light output of a decorative light string after a testing period expressed as a percentage of light output of that same string following a 24-hour seasoning period.
- E. Series Block - A number of lamps connected in series, or utilizing a series connection. Additional series blocks can be added to the circuit (i.e., DLS) utilizing parallel connections (e.g., a 70-lamp light string could have two 35-lamp series blocks connected in parallel).
- F. Watts per Lamp – The input power divided by the number of lamps on the decorative light string (or strings, in the case of power adapters or controllers that can accommodate multiple strings).
- G. V RMS AC – The measured root-mean-square value of a voltage with alternating current.

2) **Reference Standards:** Relevant standards include, but are not limited to:

ASTM International (ASTM)

ASTM G 154 – 05, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*

Canadian Standards Association (CSA)

CSA-22.2 No.37-M1989 (R2004) *Christmas Tree and Other Decorative Lighting Outfits*

Commission Internationale de l’Eclairage (CIE)

CIE 84-1989, *The Measurement of Luminous Flux*

CIE 127-1997, *Measurement of LEDs*

Illuminating Engineering Society of North America (IESNA)

IESNA TM-16-05, *IESNA Technical Memorandum on Light Emitting Diode (LED)*

Sources and Systems

Underwriters Laboratories Inc. (UL)

UL 588-2004, *Standard for Seasonal and Holiday Decorative Products*

3) **Qualifying Products:** For a decorative light string to qualify for ENERGY STAR, it must:

- a. comply with the definition in Section 1A, and
- b. undergo the testing and meet the prescribed performance requirements in Section 4 of this document.

4) Testing and Energy-Efficiency Specifications for Qualifying Products:

(Note: A random sample of three (3) strings of the same model shall be subjected to each of the tests in this section. Different samples shall be used for the electrical test, the lifetime test, and the weathering test. The samples used for the inspection may also be used for one of the subsequent tests.)

Criteria Item	ENERGY STAR Requirements	Sample Size/Specific Requirements	Laboratory Requirements
A. Inspection			
Number of Lamps per String	For all strings in the sample, the number of lamps indicated on the packaging must equal the number of lamps on the strings.	3 decorative light strings of the same model shall be used to determine compliance with all of the inspection requirements. This same sample of strings may also be used for one of the three tests (i.e., electrical, life or weathering).	Must use an independent laboratory suitably qualified for conducting these tests, with accreditation from NVLAP or one of its MRA signatories for testing Energy Efficient Lighting Products.
Replaceable Lamps	If the string has replaceable lamps, the socket and lamp must have a marking or means to ensure correct insertion of replacement lamps.		
Safety Requirements	All strings must comply with UL 588 (for the United States) and CSA-22.2 No.37-M1989 (for Canada).	UL or CSA requirements, as appropriate.	Must use an OSHA NRTL laboratory.
Rated for indoor or indoor/outdoor applications	A label on the string shall indicate whether it is rated for indoor-only or indoor/outdoor use.	3 decorative light strings of the same model shall be used to determine compliance with all of the inspection requirements. This same sample of strings may also be used for one of the three tests (i.e., electrical, life or weathering).	
Warranty	A warranty shall be provided and may either be printed on the packaging or included as an insert. Warranty statement must include: 1) minimum 3-year warranty under normal residential seasonal use against all product defects; and 2) provide either a toll-free telephone number, or mailing address, or email and website address for consumer complaint resolution.		

B. Electrical Requirements¹			
Input Power ²	<p>The input power consumption per lamp on each of the three strings in the sample shall not exceed 0.20 watts.</p> <p>For decorative light strings that modulate in their power use (e.g., flashing, changing color) energy use shall be measured over a time period of five (5) or more complete modulation cycles, averaged, and recorded as the input power.</p>	3 decorative light strings of the same model.	Must use an independent laboratory suitably qualified for conducting these tests, with accreditation from NVLAP or one of its MRA signatories for testing Energy Efficient Lighting Products.
Over-Voltage	<p>Average percentage of failed lamps on all three strings in the sample shall be no greater than 3%.</p> <p>Energize light strings at 132 V \pm 1 V RMS AC for one hour and examine for failure. If any have failed, count the number of lamps that have failed (as per definition 1.B) and calculate the failed lamps as a percentage of total lamps on the three strings.</p>		
C. Lifetime Requirements³			
Maintained Light Output	For strings with colored lamps, the average maintained light output shall be no less than 70%. For strings with white lamps or any phosphor-based lamps, the average shall be no less than 50%.	3 decorative light strings of the same model.	Must use an independent laboratory suitably qualified for conducting these tests, with accreditation from NVLAP or one of its MRA signatories for testing Energy Efficient Lighting Products.
Failed Lamps	The average percentage of failed lamps on all three strings in the sample shall be no greater than 3%.	See Appendix A for string testing configuration and test steps.	

¹ For electrical testing, operate the decorative light strings for a 24 hour (\pm 1%) seasoning period at 120 V \pm 1 V RMS AC, prior to testing.

² Measure input power and current at 120 V \pm 0.5 V RMS AC. For systems with power adapters or controllers that can accommodate multiple light strings, the input power shall be measured with the rated maximum number of strings attached.

³ For lifetime and weathering tests, operate the decorative light strings for a 24 hour (\pm 1%) seasoning period at 120 V \pm 1 V RMS AC, prior to testing.

D. Weathering Requirements³ (NOTE: Strings rated for indoor-only use shall not be subjected to this test.)			
Maintained Light Output	For strings with colored lamps, the average maintained light output shall be no less than 70%. For strings with white lamps or any phosphor-based lamps, the average shall be no less than 50%.	3 decorative light strings of the same model. Weathering condition as specified in Cycle 7 of Table X2.1 of ASTM G154-05.	Must use one or two independent laboratories suitably qualified for conducting these tests. Any laboratories used must have accreditation from NVLAP or one of its MRA signatories (see footnote) ⁵ .
Failed Lamps	The average percentage of failed lamps on all three strings in the sample shall be no greater than 3%.	See Appendix A for string testing configuration and test steps.	
E. Product Packaging for Consumer Awareness Requirements			
Product Suitability	Packaging must state product's suitability for use indoor-only or indoor/outdoor use.		
Product Description	1) Number of lamps on the decorative light string, 2) Total lighted length of string in metric and imperial units, and 3) Total rated wattage of decorative light string.		
Correlated Color Temperature for White-light Strings	Packaging must indicate if "warm-white", "pure-white" or "cool-white" lamps. These three terms pertain to the correlated color temperature (CCT) of the white-light lamps: Warm-white < 3500 CCT Pure-white 3500 – 5000 CCT Cool-white > 5000 CCT		

⁵ The laboratory conducting the multiple cycles of ASTM G154 – 05 must have certification for conducting this test: ASTM G 154 – 05, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*. The laboratory conducting the light measurement test (which may be the same laboratory that conducted the ASTM G154 – 05 test) must have NVLAP certification for testing Energy Efficient Lighting Products.

5) Qualification Process: The following section describes the steps to be followed in order to qualify decorative light strings as ENERGY STAR.

- A. The Partner must submit a **Product Light String Qualification Form** to qualify DLS models (i.e., SKU #) as ENERGY STAR. This form will be available on EPA's website: www.energystar.gov

- B. Each DLS model must meet all the performance requirements established in Section 4 of this document. Compliance with the ENERGY STAR requirements may be demonstrated by testing a sample of strings or derived from testing a sample of strings from within the same product family (see Appendix B *Product Family* for details). Partners must obtain and submit required documentation to meet the specifications for qualifying products listed in Section 4.

- C. Each Qualification Form submitted must be accompanied by a signed copy of the Test Report and a copy of the Laboratory Certification of Accreditation, for each laboratory that participated in qualifying the products listed on the Form. The signed test report must be provided by an independent laboratory accredited for testing Energy Efficient Lighting Products,⁶ by NVLAP or one of its Mutual Recognition Arrangement (MRA) signatories. Partners should obtain from the laboratory its certificate of accreditation and submit to ENERGY STAR. The test report must indicate that the model or family meets all the requirements of this specification. Qualification Forms where the performance of the string is determined by testing a different model in the same product family need only reference to the string that was tested and discuss how this string is part of that same product family. Incomplete test reports, product packaging sample, or qualification forms will not be accepted or processed for ENERGY STAR qualification.

- D. Partners must submit "electronically" a completed copy of the ENERGY STAR *Decorative Light String Qualification Form*, to the email address listed on the form.

- E. Partners shall submit either an electronic draft or hard-copy mock-up of the packaging for the specific model or family they are qualifying. One copy per family (if labeling is the same for all models) is sufficient. Packaging must meet all of the requirements that are identified under Section 4, E. **Product Packaging for Consumer Awareness Requirements** of this document. Failure to meet the

⁶ The laboratory conducting the multiple cycles of ASTM G154 – 05 must have certification for conducting this test: ASTM G 154 – 05, *Standard Practice for Operating Fluorescent Light Apparatus for UV Exposure of Nonmetallic Materials*.

packaging requirements will delay the qualification process and the DLS model or family in question will not be qualified until all packaging requirements are met. The specific qualified model or family must be distributed within this approved product packaging. If products are found being sold or distributed in alternative non-approved packaging, that model will be immediately disqualified from the ENERGY STAR for failure to meet the criteria. If a Partner has multiple cases where products are being sold in unapproved packaging, then it may result in their ENERGY STAR Partner Arrangement to be terminated.

- F. Decorative light string models that qualified for ENERGY STAR in a previous year may remain qualified without the submission of new test data if the light string model designs have not been modified in any way and the ENERGY STAR specification has not changed. Manufacturers are held accountable for the qualification of any decorative light strings marketed as ENERGY STAR, including models in a product family that were not tested directly. All decorative light strings (model numbers) using the ENERGY STAR mark must have an accepted qualification form submitted to ENERGY STAR.

- 6) Private Labeling Products:** Manufacturers, distributors, retailers, and other ENERGY STAR Partners may purchase existing qualified decorative light strings and submit them for listing on the qualified product list by completing and submitting a *Private Labeler* qualification form and product packaging draft for review and approval. Once the private labeler form and an electronic draft or hard-copy mock-up of the packaging has been reviewed and accepted, the private labeling Partners will receive a conformation from ENERGY STAR stating that this model will be added to the Decorative Light String qualified product list and can begin to use the ENERGY STAR mark on its packaging and be marketed as an ENERGY STAR product.

Partners must submit the exact information their supplier has submitted to ENERGY STAR (since the products are exactly the same) for each of their privately labeled decorative light strings. If incorrect information is submitted, the model will not be qualified as ENERGY STAR until the correct information has been submitted.

The private labeled products must have the same model numbers as the original qualified products; however, they will appear as different brand names on the qualified product list posted on the website.

- 7) **Effective Date:** The effective date for the ENERGY STAR Program Requirements for Decorative Light Strings version 1.4 is March 1, 2008.
- 8) **Future Specification Revisions:** ENERGY STAR reserves the right to change the specification should technological and/or market changes affect its usefulness to consumers, industry, or the environment. ENERGY STAR will continue to monitor decorative light string technology and initiate an update to this specification if and when necessary. In addition, ENERGY STAR will focus on several issues that may also warrant a revision to the specification, including:
- a) increasing the minimum levels of maintained light output of strings with white-light lamps or phosphor-based lamps from 50%;
 - b) the number of cycles in the weathering test;
 - c) the duration of the over voltage test;
 - d) the applicability of this specification to other decorative lights including screw-in C7 and C9 replacement lamps and light ropes;
 - e) the adaptation of this specification to a commercial grade ENERGY STAR specification;
 - f) the establishment of an initial light output or brightness measurement test;
 - g) the use of alternative metrics to a maximum wattage per lamp (e.g., efficacy requirement);
 - h) the inclusion of a cold temperature test; and
 - i) the addition of a requirement that the lighting testing laboratories will have certification for the actual lighting technologies being tested, once industry promulgates an appropriate voluntary testing standard.

In keeping with current policy, any revisions to the specification will be arrived at through stakeholder discussion and consultation.

APPENDIX A

Assemble the three decorative light strings into three flat test configurations, as illustrated in Figure 1. For each, wrap the string around a rigid board or frame so that all are mechanically supported and oriented with the lamps directed outward. Tape the assembly together with electrical tape to maintain the relative positioning of the lamps throughout the test. Next, for its optical properties, white Teflon[®] tape shall be wrapped around the assembly to completely cover the electrical tape and wiring harnesses. Ensure that the Teflon tape does not cover any part of the lamp or lamp socket.



Figure 1. A mounted decorative light string prepared for testing.

Measure the light output of the assemblies while operating at $120\text{ V} \pm 0.5\text{ V RMS AC}$, $25^{\circ}\text{C} \pm 5^{\circ}\text{C}$ and following the guidelines contained in CIE Publication 84-1989, *The Measurement of Luminous Flux*. For decorative light strings that modulate their light output (e.g., flashing, changing color), light output shall be measured over at least five (5) complete cycles.

Lifetime test:

Keeping the testing assemblies intact (i.e., do not remove the tape, or move any of the lamps), operate each assembly for 1000 hours ($\pm 1\%$) continuously. This period of operation (41 days, 16 hours) may be conducted using a test bench facility (i.e., outside the measuring device), provided that none of the lamps in any of the assemblies have been moved relative to each other.

Weathering Test:

Keeping the testing assemblies intact, load them into the testing chamber. The decorative lamp strings under test shall be operated for the duration of this test at $120\text{ V} \pm 3\text{ V RMS AC}$ inside the testing chamber. Each cycle of this test includes 8 hours of UV light (340 nm at $1.55\text{ W/m}^2/\text{nm}$) at 60°C , 0.25 hours of water spray, and 3.75 hours of

condensation at 50°C. The strings shall be subjected to 20 consecutive iterations of Cycle 7 under Table X2.1 of ASTM G154-05 for a total of 240 hours.

After completing the lifetime test or weathering test, conduct a second measurement of the light output on the respective sample of lamps following the same procedure above. Calculate the average maintained light output for the three strings tested relative to the initial average measurement for those same strings.

Count the number of failed lamps (as per definition 1.B) and calculate the failed lamps (if any) as a percentage of total lamps on the three strings, rounding the percentage up to the nearest whole number.

APPENDIX B PRODUCT FAMILY

The Environmental Protection Agency (EPA) recognizes that there are similarities between the various models of decorative light strings, which would allow manufacturers to group certain strings together into product “families” and reduce testing burden. EPA therefore allows manufacturers to test a sample of strings from one model in a product family from which it may certify compliance for the entire product family.

The ENERGY STAR Decorative Light Strings specification is built around three critical Test Groups:

1. Electrical Tests (i.e., Power Test and Over-Voltage Test)
2. Lifetime Test
3. Accelerated Weathering Test

EPA recognizes that for many decorative light strings, there are commonalities in design and construction, such as two models having same optical lens or wiring harness. For two or more strings with common design or construction characteristics, EPA recognizes that test results from a sample of one of those strings may be representative of other models for that Test Group.

The following Test Groups are proposed as ways to minimize testing burden on manufacturers. Criteria are provided below to define how manufacturers may apply the same test report to different model numbers. Remember, Partners shall provide appropriate data in each of the Test Groups for all model submitted to be considered for qualification.

Test Group A. Electrical Tests

DLS models meeting all of the following criteria may share the same electrical test data for purposes of qualification.

- Utilize the same light source technology – all DLS must be of the same light source, such as LED or incandescent.
- Have the same number of lamps per series block – the DLS can have different total lamps overall, but must all share the same number of lamps per series block.
- Have the same wattage per series block.
- Are otherwise equivalent electrical circuits – there are no other features in the electrical circuit that affect the power consumption / efficiency of the string.

Test Group B. Lifetime Test

DLS models meeting all of the following criteria may share the same lifetime test data for purposes of qualification.

- Produce the same color light – all DLS must be of the same lamp color. For multiple colored strings, the string must be qualified by testing and qualifying solid color strings containing each of the colors.
- Have the same RMS current per series block.
- Have a lamp lens cover of equivalent or smaller size, meaning less surface area and a smaller diameter. For example, if a manufacturer tests and qualifies a C6 shape, an M5 or a G3 could be included in the same product family, however testing and qualifying a G3 would not enable C6 lamps to be included in the same lifetime test family.
- Half-wave and full-wave may be grouped together in the same family, but only if half-wave strings are tested. If full-wave strings are tested, these results cannot be used to qualify half-wave strings.

Test Group C. Weathering Test

For the weathering test, the Partners must treat phosphor based and non-phosphor based lamps in separate families. In addition, multi-colored DLS may be used to qualify solid-color DLS having those colors represented on the multi-colored string. DLS models meeting these requirements and all of the following criteria may share the same weathering test data for purposes of qualification.

- Be either all phosphor-based lamps or all non-phosphor based lamps,
- Have the same socket types (i.e., replaceable versus non-replaceable),
- Incorporates the same material in the lamp lens cover / diffuser, wire and socket, and
- Have a lamp lens cover of equivalent or smaller size, meaning less surface area and a smaller diameter. For example, if a manufacturer tests and qualifies a C6 shape, an M5 or a G3 could be included in the same product family and be qualified without testing, however testing and qualifying a G3 would not enable C6 lamps to be included in the same family.