Test Procedures for Light-Emitting Diode Lamps Notice of Proposed Rulemaking

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Department of Energy
Energy Efficiency & Renewable Energy
Docket Number: EERE-2011-BT-TP-0071
LEDLamps-2011-TP-0071@ee.doe.gov

May 3, 2012

Welcome

- Introductions (around the room)
- Role of the Facilitator
- Ground Rules
  - Listen as an ally
  - Focus on issues
  - Use short, succinct statements/keep to the point
  - Hold sidebar conversations outside the room
  - One person speaks at a time (raise hand to be recognized; state your name for the record)
  - Set cell phones to silent/vibrate
- Housekeeping Items
- Agenda Review
- Opening Remarks

Agenda

9:00 – 9:15 am	Welcome, Introductions, Opening Statements
9:15 – 9:30 am	Rulemaking Process and Scope
9:30 – 10:15 am	Test Procedure for Input Power, Lumen Output, and Correlated Color Temperature (CCT)
10:15 – 10:30 am	Break
10:30 – 12:15 pm	Test Procedure for Rated Lifetime
12:15 – 12:30 pm	Questions and Closing Remarks

Listening Via the Webcast

- The Department is broadcasting this meeting live over the Internet.
- DOE is providing the webcast to accommodate stakeholders that are unable to attend the public meeting in person.
- The web broadcast allows stakeholders to listen in and view the slides.
- All stakeholders are encouraged to submit written comments after the public meeting.

Purpose of the Public Meeting

- Present DOE's proposed test procedures for light-emitting diode (LED) lamps.
- Invite comment on the test procedure notice of proposed rulemaking (NOPR) document.
- Discuss next steps in the rulemaking.
- Invite participants to provide summary comments or statements and raise additional issues for discussion.

Issues for Discussion

Issue Box: DOE welcomes comments, data, and information concerning its proposed test procedures for LED lamps. Issues that correspond to those raised in DOE's published material will be numbered in accordance with that material. Whether invited by an issue box or not, comments are welcome on any part of DOE's analysis.

Issue box numbering corresponds to the list of issues published at the end of the NOPR document, available at:

http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/led_tp_nopr_frnotice.pdf

The deadline for submitting comments is **June 25, 2012**.

Opening Remarks

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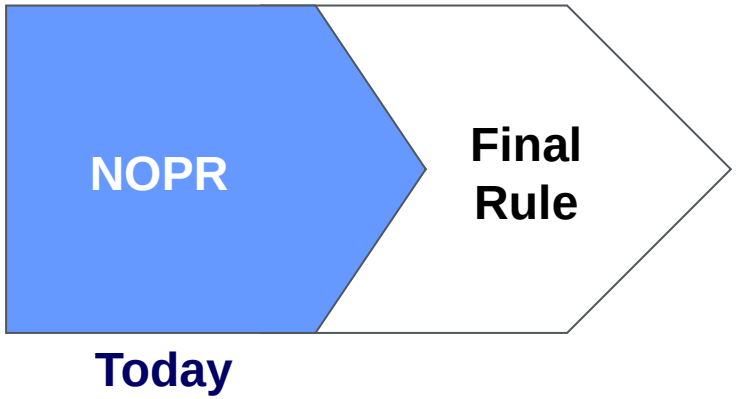
Meeting participants are invited to provide opening remarks or statements at this time.

Public Meeting Slides Topics

1. Rulemaking Process and Scope
2. Test Procedure for Input Power, Lumen Output, and CCT
3. Test Procedure for Rated Lifetime

Test Procedure Rulemaking Process

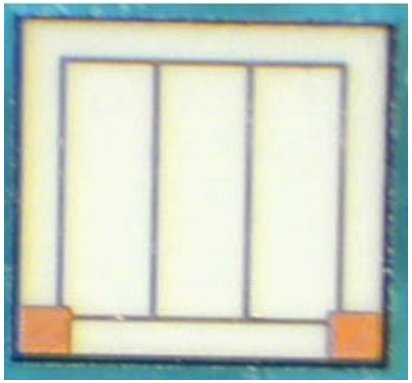


Milestone	Date
Notice of Proposed Rulemaking (NOPR) Publication	*April 9, 2012*
NOPR Public Meeting	*May 3, 2012*
Comment Period Ends	*June 25, 2012*
Final Rule Publication (projected)	*November 2012*

Scope of Applicability

- This rulemaking is applicable to integrated LED lamps as defined by ANSI/IESNA RP-16-2010.
- An **integrated LED lamp** is composed of an LED source, such as LED packages or LED arrays, LED driver, ANSI standard base, and other optical, thermal, mechanical, and electrical components.
- An **LED source** is the light producing component within an LED lamp. It is the assembly of components or dies, including electrical connections, printed on a circuit board or substrate.

Integrated LED Lamp
Source: Philips



LED
Source: Cree

LED Source
Source: Journée

Issues for Discussion

Issue 1: DOE requests comment on both proposed scope and the definition of LED lamps.

Public Meeting Slides Topics

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1. Rulemaking Process and Scope
2. Test Procedure for Input Power, Lumen Output, and CCT
3. Test Procedure for Rated Lifetime

Proposed Test Procedure Overview

- DOE proposes to adopt IES LM-79-2008, “Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products” with some modifications.
  - Industry accepted standard for determining input power, lumen output, and CCT.
  - Referenced by ENERGY STAR’s Integral LED Lamps specification.
  - Recommended by FTC for testing LED lamps.
  - Required for voluntary participation in DOE’s Lighting Facts® program.

IES LM-79-2008 Summary

- The following test conditions, test setup, and test measurement requirements are adopted without modification from IES LM-79-2008:
  - Air temperature and air movement
  - Power supply and voltage regulation
  - Lamp mounting
  - Electrical instrumentation and electrical settings
  - Lumen output measurement using an integrating sphere system or goniophotometer system
  - Method of measuring CCT

Issue 2: DOE requests comment on the proposed incorporation of IES LM-79-2008 for determining lumen output, input power, and CCT.

Air Movement

- IES LM-79-2008 specifies that air flow around the LED lamp should be such that lumen output measurement is not affected.

- IES LM-9-2009 provides additional specification for air movement. It specifies a single-ply tissue paper should be held in place of the lamp and visual observations be made of air-draft.

Issue 3: DOE requests comment on whether air movement should be specified in more detail than that provided by IES LM-79-2008.

Lamp Orientation

- Lamp orientation is known to affect thermal conditions within the lamp, which may affect lumen output.
- IES LM-79-2008 specifies that the lamp should be tested in the operating orientation recommended by the manufacturer for the intended use of the LED lamp.
- However, manufacturers typically do not specify the operating orientation in product literature.
- DOE proposes that an equal number of lamps be operated in the base up, base down, and horizontal orientations for testing.

Issue 4: DOE requests comment on operating an equal number of lamps in the base up, base down, and horizontal orientations throughout testing.

Electrical Settings: Input Characteristics

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- DOE proposes that LED lamps should be tested at the rated voltage as specified in IES LM-79-2008.
- DOE proposes that LED lamps with multiple operating voltages should be tested at 120 volts, if the lamp is rated at 120 volts, because this is the most common operating voltage of available lamps.
- If the lamp is not rated at 120 volts, DOE proposes that it should be tested at the highest rated voltage.
- For dimmable lamps, DOE proposes that the lamp should be tested at the maximum input power as specified in IES LM-79-2008.

Electrical Settings: Multiple Modes of Operation

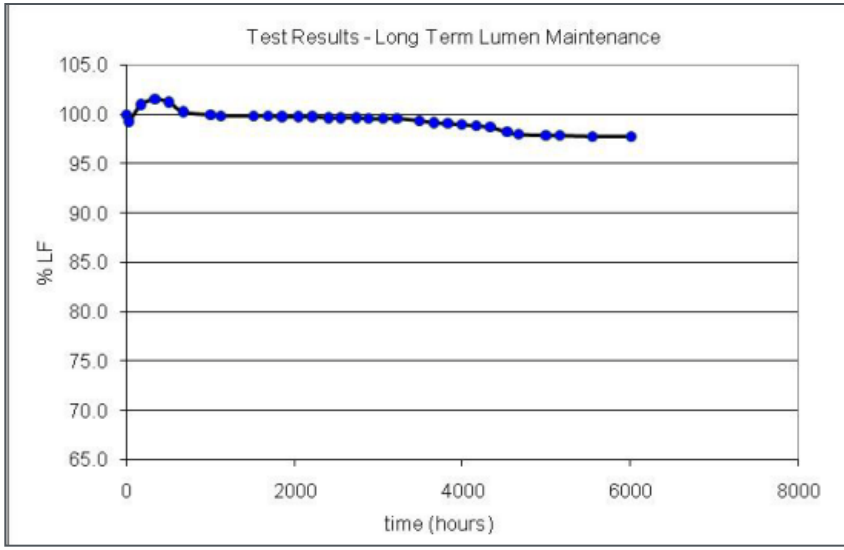
- IES LM-79-2008 specifies that lamps with multiple modes of operation, such as variable CCT, should be tested in each mode of operation.
- DOE has not identified any lamps that function at multiple modes of operation and requests information on these products.

Issue 5:

- DOE requests comment on testing LED lamps at the rated voltage for single voltage lamps and testing lamps with dimming capability at the maximum input power.
- Further, DOE requests comment about testing LED lamps that are rated to operate at multiple voltages at 120 volts or the highest rated voltage.
- Finally, DOE requests comment on whether LED lamps with multiple modes of operation are available and the CCT value at which these lamps should be tested.

Lamp Seasoning

- IES LM-79-2008 specifies no seasoning requirement.
- DOE proposes that LED lamps be seasoned for 1,000 hours prior to lamp stabilization and lumen output measurement.
- Industry has observed an increase in lumen output during the first 1,000 hours of operation of an LED source.



Source: Richman, Eric. "Understanding LED Tests: IES LM-79, LM-80, and TM-21." DOE SSL Workshop, July 2011.

Issue 6: DOE requests comment on seasoning the LED lamp for 1,000 hours before collecting lumen output data.

Lamp Stabilization

- DOE proposes that an LED lamp reaches stability when the variation of at least 3 readings of input power and lumen output taken 15 minutes apart is less than 0.5% as specified in IES LM-79-2008.

- The variation should be calculated as follows:

$$Variation\ of\ \ at\ least\ three\ readings = \frac{maximum - minimum}{minimum}$$

- The equation clarifies the method specified in IES LM-79-2008.

Issues for Discussion

Issue 7: DOE requests comment on stabilizing the lamp until the variation of at least 3 readings of the lumen output and electrical power, taken 15 minutes apart, is less than 0.5 percent. DOE also requests comment on its clarification of the variation calculation to be the difference of the maximum and minimum values divided by the minimum value.

Lumen Output Measurement: All Lamps

- DOE proposes that either a sphere-spectroradiometer, sphere-photometer, or a goniophotometer be used to measure lumen output as specified in IES LM-79-2008.

Issue 8: DOE requests comment on measuring the lumen output of the LED lamp using a sphere-spectroradiometer system, sphere-photometer system, and goniophotometer system. In particular, DOE requests comment on whether the measurements from each method are similar and consistent.

Lumen Output Measurement: Directional Lamps

- DOE proposes that the total lumen output be measured for directional LED lamps rather than the beam lumens (or zonal lumens).
  - Other directional lamp technologies measure total lumen output for reporting 'brightness' on FTC's Lighting Facts label.
  - Different directional lamp technologies cannot be compared if directional LED lamps measure beam lumens while other technologies measure total lumens.

Issue 9: DOE requests comment on measuring total lumens for directional LED lamps instead of beam lumens.

Sampling Plan

- DOE proposes that a minimum of 21 LED lamps should be tested.
- A minimum of 3 lamps should be selected per month for 7 months of production out of a 12 month period.
- If production occurs in fewer than 7 months of the year, 3 or more lamps should be selected evenly for each month of production.
- Sample sizes greater than 21 should be multiples of 3 to test an equal number of lamps in each orientation.

Issue 21: DOE requests comment on the proposed sample size requirements for testing LED lamps.

Rounding Requirements

- DOE proposes that the input power of all test units be averaged and the average value be rounded to the nearest tenths digit.

- DOE proposes that the lumen output and CCT of all units be averaged and the average values be rounded to the nearest tens digit.

- DOE proposes that the estimated annual energy cost ($/yr) be calculated as the product of the average input power (kW), electricity cost rate ($/kWh), and estimated average use (hrs/day). The resulting value should be rounded to the nearest cent.

Issue 10: DOE requests comment on the proposed calculation and rounding requirement for lumen output, input power, CCT, and estimated annual energy cost.

Public Meeting Slides Topics

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1. Rulemaking Process and Scope
2. Test Procedure for Input Power, Lumen Output, and CCT
3. Test Procedure for Rated Lifetime

Approaches Considered to Determine Rated Lifetime

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Approach 1: L_{70} of LED Lamp	Approach 2: ENERGY STAR Lifetime Projection	Approach 3: Projection of IES LM-79-2008 Data	Approach 4: Projection of LED Source Data using IES TM-21-2011
Lumen output of the LED lamp is measured using IES LM-79-2008 until half the sample size is below 70% of initial lumen output.	Lumen maintenance of LED lamp is measured for 6,000 hours using IES LM-79-2008. Maximum rated lifetime claim is dependent on minimum lumen maintenance at 6,000 hours.	Lumen output of the LED lamp is measured for 6,000 hours minimum using IES LM-79-2008 and projected to L_{70} life of the lamp.	Lumen maintenance of LED source is measured using IES LM-80-2008 and projected to L_{70} using IES TM-21-2011. Maximum rated lifetime cannot exceed 25,000 hours.

Approach 1: Measuring L_{70} of LED Lamp

- Advantages:
  - LED lamp, rather than LED source is tested to determine rated lifetime.
  - The reported value of rated lifetime is the observed value when lumen output reaches 70% of initial lumen output (L_{70}). That is, this approach does not require projecting the rated lifetime.

- Disadvantages:
  - Testing the LED lamp until the lumen output reaches 70% of initial lumen output can take a very long time (almost 3 years for 25,000 hours).
  - Because LED lamps are an emerging technology and evolving quickly, the product may be obsolete by the time testing is completed.

Approach 2: ENERGY STAR Lifetime Projection

- Advantages:
  - LED lamp, rather than LED source, is tested for 6,000 hours to project rated lifetime.
  - Lumen maintenance is projected using minimum 6,000 hours of data, therefore, testing is not as time consuming as Approach 1 (approximately 9 months compared to 3 years).

- Disadvantages:
  - LED lamp failure mechanisms, other than lumen depreciation, are not accounted for.
  - Cycling is not a proven source of failure for LED lamps.

Approach 3: Projecting IES LM-79-2008 Data

- Advantages:
  - Projects rated lifetime using LED lamp performance data rather than LED source performance data.
  - Projection of rated lifetime is based on minimum 6,000 hours of data, which is not as time consuming as Approach 1.

- Disadvantages:
  - Standard method to make a projection using IES LM-79-2008 data has not yet been developed.
  - It may not be feasible to develop a method for projecting IES LM-79-2008 data in a timely manner for the FTC Lighting Facts label.

Approach 4: Projecting LED Source Data using IES TM-21-2011

- Advantages:
  - Uses accepted industry standard IES TM-21-2011 to project lumen output of LED sources as determined by IES LM-80-2008.
  - Maximum allowable projection cannot exceed 25,000 hours.
    - Ensures exceedingly large projections are not made solely on LED source data.
    - Currently unknown how long the LED driver may last or how the system effects may impact LED lamp lifetime.
  - Less burdensome than testing the lamp for 6,000 hours according to LM-79 because lumen maintenance data of LED sources is often available from LED source manufacturers.

Approach 4: Projecting LED Source Data using IES TM-21-2011

- Disadvantages:
  - Projects LED source data rather than LED lamp data.
  - Proposed approach does not account for LED driver degradation and failure, or effect of interactions among LED sources and between LED sources and other components within the lamp.
    - Standardized test methods to determine the impact of these components on rated lifetime have not yet been established

- Therefore, DOE proposes approach 4 because it uses a standardized test and projection method and has minimal test burden.

Issue 11: DOE requests comment on the relative costs and benefits of the 4 approaches considered in the NOPR to determine rated lifetime of an LED lamp.

Definition of LED Lamp Rated Lifetime

- DOE proposes to define the rated lifetime of an LED lamp as the time at which the lumen output of the LED source within the lamp falls below 70% of initial light output (L_{70}).

Issue 12: DOE requests comment on the proposed definition of the rated lifetime of an LED lamp.

Steps to Determine Rated Lifetime

Determine in-situ temperature

- Perform an in-situ temperature measurement test (ISTMT) to determine the case temperature of the LED source at which lumen maintenance data should be used.

Obtain lumen maintenance data

- Directly from LED source manufacturers.
- By interpolating the data available at 2 other case temperatures that bound the in-situ temperature.
- By measuring the lumen maintenance at the in-situ case temperature.

Project lumen maintenance data

- Use the method described in IES TM-21-2011 to project LED source lumen maintenance data.
- Maximum allowable rated lifetime projection is 25,000 hours.

In-situ Temperature Measurement Test

Determine in-situ temperature

Obtain lumen maintenance data

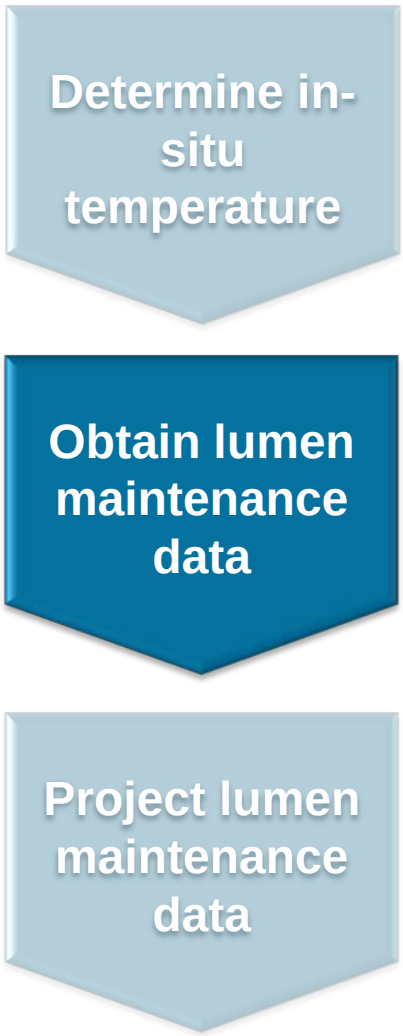
Project lumen maintenance data

- DOE proposes that the test setup, conditions, test equipment, instrumentation, and test box material and construction specified in UL 1993-2009 be used for performing the ISTMT.
- DOE proposes a thermocouple should be attached to the temperature measurement point (TMP) described by the LED source manufacturer as specified in Appendix D of the ENERGY STAR specification.
  - The temporary hole for inserting the thermocouple should be tightly sealed during testing.
  - The ENERGY STAR specification provides guidelines to attach the thermocouple in the LED lamp.

Issues for Discussion

Issue 17: DOE requests comment on adopting section 8.5, 8.13, 8.14, 8.15, and 9 of UL 1993-2009 and the practicality of the thermocouple attachment requirements for performing the ISTMT.

Test Conditions: Case Temperature and Drive Current



- DOE proposes the test conditions to be as specified in IES LM-80-2008.
- DOE proposes to test the LED source only at the in-situ case temperature, instead of the 3 temperatures specified in IES LM-80-2008.
- DOE proposes the drive current passing through the LED source should be equal to or greater than the drive current passing through the LED source in the LED lamp.

Test Conditions: Air Temperature and Air Movement

Determine in-situ temperature

- DOE proposes the temperature of the surrounding air during testing should be maintained between the case temperature and 5 °C below the case temperature as specified in IES LM-80-2008.

Obtain lumen maintenance data

- DOE proposes the air movement to be such that thermal stratification is avoided as specified in IES LM-80-2008.

Project lumen maintenance data

Issue 13: DOE requests comment on operating the LED sources at the in-situ case temperature and drive current as well as the ambient conditions for testing. DOE also requests comment on whether the measurement location for air temperature near the LED source and airflow around the LED source should be further specified.

Operating Orientation

Determine in-situ temperature

- DOE proposes that LED sources should be operated in the orientation specified by the source manufacturer and spaced to allow airflow around each unit as stated in IES LM-80-2008.

Obtain lumen maintenance data

- DOE is not proposing a specific operating orientation for LED sources because the case temperature is controlled during testing, thereby minimizing the effect of orientation on lumen output.

Project lumen maintenance data

Issue 14: DOE requests comment on whether the operating orientation of LED sources affects the lumen depreciation over time.

External Driver

Determine in-situ temperature

Obtain lumen maintenance data

Project lumen maintenance data

- DOE proposes that an external driver compliant with manufacturer's guidance be used to drive the LED source as specified in IES LM-80-2008.

Issue 15: DOE requests comment on whether the requirement that the external driver used for testing LED sources be as specified by the manufacturer needs further clarification.

Instrumentation to Measure Lumen Output

Determine in-situ temperature

Obtain lumen maintenance data

Project lumen maintenance data

- IES LM-80-2008 specifies that the lumen output of the LED source be measured using a spectroradiometer.
- Instead, DOE proposes that a sphere-spectroradiometer system, sphere-photometer system, or a goniophotometer should be used for measuring the lumen output of the LED source.

Issue 16: DOE requests comment on using a sphere-photometer system or a goniophotometer for measuring the lumen output of LED sources in addition to the sphere-spectroradiometer system specified in section 6.2 of IES LM-80-2008.

Lumen Maintenance Measurement

Determine in-situ temperature

Obtain lumen maintenance data

Project lumen maintenance data

- DOE proposes that lumen maintenance be measured as specified in IES LM-80-2008 and IES TM-21-2011.
- DOE proposes that the following guidelines from the ENERGY STAR guidance document should be adopted:
  - All LED source units should be of the same CCT.
  - Guidance on testing LED sources of a lamp that has the following types of sources:
    - Both phosphor-converted white and single-color LED packages.
    - LED arrays with either a common phosphor layer or phosphor layers over individual dies.
    - LED array that is an assembly of LED packages each with its own phosphor layer.

Issues for Discussion

Issue 18: DOE requests comment on adopting relevant guidelines from the ENERGY STAR® guidance document for measuring lumen maintenance.

Projected Rated Lifetime and Rounding Requirements

Determine in-situ temperature

Obtain lumen maintenance data

Project lumen maintenance data

- DOE proposes that the rated lifetime should be projected as specified in IES TM-21-2011.
- If the projected rated lifetime is greater than 25,000 hours, the maximum rated lifetime should be 25,000 hours.
- If the projected rated lifetime is less than 25,000 hours, the rated lifetime should be the projected value.
- The rated lifetime should be calculated in number of years based on 3 hours per day of operation. The resulting value should be rounded to the nearest tenth of a year.

Issues for Discussion

Issue 19: DOE requests comment on adopting section 5.0 of IES TM-21-2011 for projecting the lifetime of the LED sources with a maximum projection of 25,000 hours.

Issue 20: DOE requests comment on the proposed rounding requirement for rated lifetime.

Issue 11: DOE requests comment on the proposed approach for determining rated lifetime of LED lamps including the proposed incorporation of specifications outlined in IES standards LM-80-2008 and TM-21-2011 and UL standard 1993-2009.

Sample Size Requirements

- DOE proposes that the sample size be as specified in IES TM-21-2011.
- At a given case temperature and drive current, at least 10 units should be tested.
  - The method of projection specified in IES TM-21-2011 cannot be used for less than 10 units.

Issue 21: DOE requests comment on the proposed sample size requirements for testing LED sources for determining the rated lifetime of an LED lamp.

Estimate Burden to Small Businesses

- DOE estimated that this rulemaking will impact 17 potential small business manufacturers of LED lamps from a total of about 32 manufacturers.
- DOE estimated that each small business manufacturer typically manufactures 17 basic models.
- The cost for testing 17 basic models for each manufacturer is:
  - Initial setup: $12,000
  - Labor cost for testing: $68,000
- The cost for changing package and product labeling as well as retail catalogs should not impose a significant burden.

Issues for Discussion

Issue 22: DOE requests comment on its estimated number of small businesses impacted by this rulemaking as well as its estimated cost and associated burden to small businesses.

DOE Seeks Comment on its Proposed Test Procedure

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- In all correspondence, include all of the following:
  - Test Procedures for Light-Emitting Diode Lamps
  - Docket Number: EERE-2011-BT-TP-0071
  - Regulatory Identification Number (RIN): 1904-AC67

- Contact information:
  - Email: LEDLamps-2011-TP-0071@ee.doe.gov
  - URL: http://www1.eere.energy.gov/buildings/appliance_standards/pdfs/led_tp_nopr_frnotice.pdf

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- Comment period closes: **June 25, 2012, 11:59 PM EDT**

Questions?