October 16, 2009

NEMA & NGLIA Draft Comments on September 18 Proposal for Energy Star Requirements for Integral LED Lamps

We are pleased to provide the following comments on behalf of the Next Generation Lighting Industry Alliance (NGLIA) and the NEMA Solid State Lighting Section. We look forward to a successful final Energy Star specification for this product category. Please contact Craig Updyke (cra_updyke@nema.org, 703 841 3294) with any questions about any of the following comments.

Reference Standards and Procedures

The Note at the bottom of page 5 states: "Integral lamps shall be measured with their integral drivers at 120 volts and 60 Hz." However, the section on page 7 on operating voltage states "Lamps shall operate at 120 or 277 volts, ±10 %." The discrepancy should be resolved.

Requirements for All Lamps

CCT and Duv

We suggest allowing all color bins specified in ANSI C78.377-2008 for products intended for outdoor applications and non-standard lamps and allowing 4200K.

In addition, on page 4 the definition of Duv should be the same as ANSI 78.377[1]. As it is stated in Draft 3 is incorrect.

Color Maintenance

The way the current draft specification is written it is somewhat ambiguous and could lead to an interpretation that the chromaticity may exceed the stated limit after 6,000 hours. However, the 6,000 hours testing is part of an accelerated lumen maintenance testing, at specific conditions (e.g. GLS replacement at 45C). Due to the long life of LED lamps in general (and to obtain the Energy Star label in due time), there is no other way to verify such maintenance criteria (whether lumen maintenance or color maintenance) but by performing an accelerated test.

CRI

We strongly encourage the DOE to maintain 80 for LED products, especially for indoor applications. Current Energy Star requirements for CFL lamps require average of 80 or greater.

DOE's "CFL Lessons Learned Report," clearly stated that the poor color quality of early CFLs was one of the reasons for slow adoption. Right now, LED lamps will need to compete with the new CFLs (typically CRI of 82), which are offered for sale at a much lower price point than LED

[1] Duv is defined as "the closest distance from the Planckian locus on the (u', 2/3 v') diagram, with + sign for above and - sign for below the Planckian locus." ANSI_NEMA_ANSLG C78.377-2008, p. 9.

lamps. If an LED lamp can not surpass or at least match a CFL on light quality, especially color quality, the adoption of LED lamps will be slow – likely the same as early CFLs.

All major LED suppliers and LED lampmakers are already making LEDs with minimum CRI 80 in 2700K-3000K CCT range.

In addition, from an LED technology stand point, if the CRI of an LED lamp is below 80, the phosphor would not likely deliver R9>0. If the LED CRI is 80 or above, the phosphor would most likely produce R9>0.

As for outdoor applications, it is not as critical to have a high CRI. DOE could consider allowing lamps for outdoors applications could have a minimum CRI of 75 (higher CCT bins are used 4200K (4000K, 4500K, or perhaps higher as per ANSI C78.377-2008).

Dimming

First, a dimming standard for integral LED lamps must be established before the Energy Star requirements can be effective. Secondly, the manufacturer should have the option of making the lamp for dimming systems or not if there is additional cost to do so. The purpose of Energy Star is to accelerate the market acceptance of quality, energy saving products. Unjustified cost increases will increase price and prevent rapid market acceptance.

Secondly, until the standard for dimming is established and the Energy Star requirements become effective for that standard, manufacturers must label their products whether or not they are dimmable and must provide information either in the carton or on a website as to which dimmers they are compatible with.

In addition, we recommend the addition of the following statements and requirements in this section. The first statement, if added, would clarify the meaning of "dimmable".

> For the purposes of this section, "dimmable" means the ability, using a standard dimmer to change the light output, either continuously or in small steps, of the integral LED lamp from full light output to a minimum sustained light output that is no more than 20% of full in the case of the continuous operation and no more than 33%of full for stepped operation (emulation of a 3-way lamp).

Addition of the following statement addresses the stated reason why dimmability is not a requirement at this time.

> Not all LED lamps need to be dimmable. Lamps that are not dimmable should be clearly indicated as such on the packaging.

Addition of following requirement would promote safety.

> Lamps that are designated non-dimmable shall not be permanently damaged when operated on a dimmer, not shall they cause the dimmer to be permanently damaged.

Power Factor

The current requirement of the DOE proposal (for lamp power >5W, power factor must be ≥ 0.70) is currently not feasible, especially when considering the lamp dimensions and that (when dimmable) the LED lamp shall be dimmable on most of the existing dimmers. Restricted dimensions (space), dimmability and such a power factor are not feasible currently, and if required will drastically delay the application of the Energy Star label for LED Replacement lamps.

We recommend changing the threshold to 7W. The reason is that it is not feasible technically to achieve PF ≥ 0.7 for lamps with power less than 7W. The high PF of 0.7 requires additional electronic components. Lamps < 7W are typically very small, therefore there is not enough space for additional components to increase PF.

We recommend for lamps of power between 7-25W a power factor of ≥ 0.6 and for lamp power greater than 25W, a PF ≥ 0.7. This is consistent with power factor categories for other products. The requirement should state clearly that it applies at 120V, 60Hz.

LED Operating Frequency

The specification of 120 Hz might cause visible flickering for some people. Flickering will be picked up by most camcorders as well, unless the maximum to minimum luminance ratio is regulated to not exceed a certain value – we would suggest 10 percent. In addition, Energy Star would be advised to consult human factor experts to confirm these flicker issues.[2]

In addition, the requirement as written excludes DC operation of LEDs. There should be some consideration of the shape of the waveform. This entire requirement needs additional thought.

EMI and RFI

In the U.S., SSL devices are governed by Part 15 of FCC regulations as an unintentional radiator. FCC Part 18 only covers RF lighting devices that ionize a gas, such as ballasts. According to the DOE document on Solid State Lighting Standards (see http://apps1.eere.energy.gov/buildings/publications/pdfs/ssl/ssl_standards.pdf), only Part 15 is applicable.

However, our companies are divided on whether Energy Star should leave an option to meet Part 18 requirements, which are more relaxed for commercial equipment, and effectively disallow those products for residential applications. Perhaps Energy Star should clarify what is meant by the word "appropriate" or, alternatively, require only Part 15 if by doing so these lamps could be used in either application.

[2] One resource is: Human Factors in Lighting, Second Edition, by Peter R. Boyce, in which the minimum recommended frequency is 150 Hz.

Audible Noise

What is the test procedure to self-certify? What standards should apply?

Transient Protection

What are the pass/fail criteria? ("Do not fail in unsafe condition" or "No damage to product"?)

Each of the lamp types listed below has specific lumen maintenance requirements. In addition to LED lumen maintenance, the SSL drive long term performance degradation should also be accounted for.

Packaging Requirements

Dimmable Lamps

Since dimmable integral LED lamps should comply with the (upcoming) standard for dimmable lamps (to be published by NEMA), the dimming range will be most likely an integral part of that standard.

In our deliberations it was considered that Energy Star may want to require lamp packaging for dimmable integral LED lamps to state the measured minimum sustained light output as a percentage of full light output.

However, in future when a lamp is claimed to be dimmable, it will have to comply with the NEMA standard and there is no need to specifically state the minimum sustained light output as a percentage of full light output.

LED MR-16 Lamps Intended for Use on Low-Voltage Circuits

An approved test method has not yet been developed, but because consumers do not know which type of low voltage transformer their fixture contains, the following text should be added and take effect when the approved method becomes available:

> LED MR-16 lamps shall not be permanently damaged by operation on any transformer type, nor shall they cause permanent damage to said transformer.

Product Equivalency Claims (for Replacement Lamps)

Can a LED Integral lamp claim equivalency to both a R30 and PAR30?

Non-Standard Lamps

Our members are somewhat divided on this category. Some favor including it, while some believe non-standard lamps should not be part of the Energy Star standard. If one of the purposes

of Energy Star is to quickly drive market acceptance of quality, energy saving products, the last thing Energy Star wants to do is to confuse the market. By including non-standard lamps, which may not properly fit in various residential applications since they would have non-standard shapes, this could lead to market dissatisfaction.

Other members have requested further explanation of the category and information on the definition of "non-standard lamp." Does this preclude a manufacturer from making a lamp in a standard outline that is not claimed to replace an existing incandescent?

Minimum Luminous Efficacy

We recommend changing this to 40 lm/W and 45 lm/W rather than the 50 and 55 that are listed. These revised values work in concert with our recommended minimum CRI of 80.

Lumen Maintenance

The ambient temperature should be reduced from 45C to 25C. It is very difficult to control the operating temperature and its tight tolerance as proposed (±1C). Firstly, (with such a low tolerance) the definition of the operating temperature needs to be clearly specified: ambient temperature within a restricted area/ volume in which the lamp is tested, distance of point of temperature measurement to lamp, measurement point on lamp, etc.: the definition and location of the measurement point can easily represent several degrees in variation! Secondly, the tolerance is too tight to be maintained as such over the full lifetime test period. (Proposal: nominal temperature ±10%)

Rapid Cycle Stress Test

Clearly a test procedure must be established and agreement reached for this test to be successful. The 25,000 hour rated life requires 35 days of testing. This will require considerable rapid cycle test space and automated monitoring to be efficient. We also read this such that rapid cycle stress testing is only required for the minimum life required of a lamp category and not for an extended life rating. For example a lamp in a category requiring 25,000 hours, L70, can be rated for 50,000 hours with additional normal life testing per the schedule provided without having to have a rapid cycle report beyond that for 25,000 hours, L70.

Replacement Lamps

Minimum Luminous Efficacy

The proposed values should be reduced to 45 lm/W and 50 lm/W. (LED lamp power <10W: 45 lm/W and LED lamp power >=10W: 50 lm/W). The charter for Energy Star is to reduce energy consumption within the U.S. As such, we would like to convert as many households to lower wattage products as fast as possible. If Energy Star is to do this, then we need to have realistic targets for efficacy. The maximum heat dissipated by the form factor of an A-lamp is roughly equivalent to 7 watts. All manufacturers will design to a 7 watt maximum. Is this low enough for industry to be considered acceptable for Energy Star? Note, as shown today, to gain Energy

Star for a 25 watt replacement will require a 4 watt bulb (at 50 lm/W efficacy), which is less than 7 watts. Are we really going to exclude a 7 watt replacement for Energy Star, just because a specification wants us to go to 4 watts? Why?

We suggest that Energy Star lower the requirements to 45 lm/W so that Energy Star can be achieved by lower wattage products earlier in the life cycle. Because the light benefits of LEDs are preferred (i.e. long life, no mercury, and instant turn-on), getting Energy Star earlier for these products will help lower the overall environmental impact of lighting

Minimum Light Output

The "40W" category is much higher than the EU requirement of minimum 350 lumens. Since all of the other recommended lumen output values equate fairly well with current EU values, we recommend that the 40W be revised to 350 lumens to be in alignment.

However, other companies believe that the table in Draft III should not be changed and that a 40W bulb should a minimum flux output of 450 lumens, not 350 lumens. We note that the European Union is requiring 470 lumens in order for a lamp to be called a 40W replacement.[3]

Omnidirectional Lamps

Minimum Light Output

To our knowledge, no 35 watt incandescent products are on the market to be replaced. However, Energy Star may wish to retain the 35 W category so that new LED products entering the market do not necessarily have to have incandescent equivalents.

Luminous Intensity Distribution

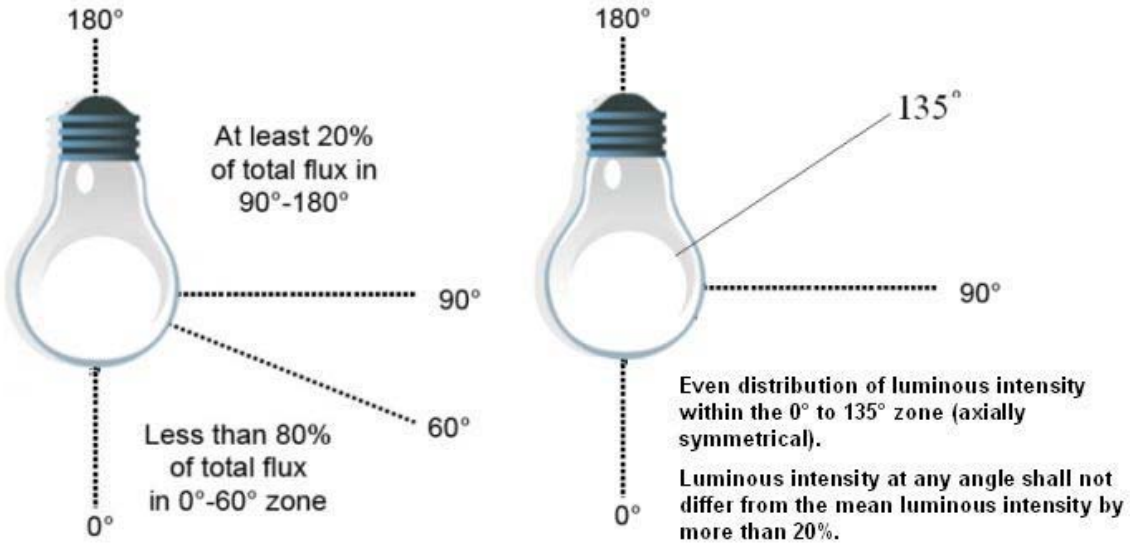
Products should have an even distribution of luminous intensity within the 0° to 120° zone (axially symmetrical). Luminous intensity at any angle within this zone shall not differ from the mean luminous intensity for the entire 0° to 120° zone by more than 25%.
There needs to be an accepted procedure for measuring Luminous Intensity over different planes. A definition of non-directional lamps should be added to provide clarity.

We strongly disagree with this significant alteration and reduction in requirements from the Draft 2 proposal. A lamp that meets the Draft 3 requirements is no longer an omnidirectional lamp. These requirements would allow for products that would produce strong dissatisfaction among most customers of incandescent replacement lamps.

Therefore, we request that a new Draft 4 specification should quantify a maximum allowable range of uniformity (+/-% from the mean) within the 0 degree to 135 degree zone, similar to the proposed specification in Draft 2.

[3] See COMMISSION REGULATION (EC) No 244/2009 of 18 March 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for non-directional household lamps

We propose amendments to the Draft 2 proposal that ameliorate each of the concerns raised by stakeholder comments that were published in the Cover Letter for Draft 3.



The Draft 3 proposal requires only that there be < 80% of the light in the 0-60 degree range, and >20 percent of the light in the > 90 degree range.

With the 80 percent proposal, Draft 3 thereby allows for several illumination patterns that would be undesirable in most customer applications for incandescent lamps, such as:

- Draft 3 allows zero light at all angles in the range 60^{o}-90^{o}. So this 30^{o}-wide zone is allowed to be completely dark.
- Draft 3 allows zero light in any subset range of angles within the range 0^{o}-135^{o}. So, there may be completely dark zones, having considerably wide angular range, anywhere within the illumination pattern.
- Draft 3 allows for an arbitrarily large intensity at any angle. So there may be intensely bright zones anywhere in the illumination pattern; effectively a beam with a surrounding low-intensity zone.
- Draft 3 does not provide any limitation on local non-uniformity. So there may be intensely bright zones adjacent to completely dark zones anywhere in the illumination pattern, as long as the pattern is vertically symmetric.

The Cover Letter for Draft 3 cites the following 3 rationales for the changes from Draft 2:

> Stakeholder comments questioned the requirement for uniformity throughout the 0° to 135° zone, pointing out that many incandescent A-type lamps do not meet this degree of uniformity, and that various distributions can meet general lighting requirements. Others expressed concern that the requirements would allow for no light in the 135° to 180° zone, the area around the base of the lamp, which is needed for table lamps and other

> applications in which the lamp is positioned base down. Finally, reference was made to European guidelines (EC No. 244/2009) defining directional lamps as all lamps with at least 80% of luminous flux in the 0° to 60° zone and defining all other distributions as non-directional. DOE has responded by adopting the non-directional lamp definition, with an adjustment to help ensure some light in the 90° to 180° zone.

Consider the first assertion from the excerpt above:

> Stakeholder comments questioned the requirement for uniformity throughout the 0° to 135° zone, pointing out that many incandescent A-type lamps do not meet this degree of uniformity [i.e. Draft 2 specification], and that various distributions can meet general lighting requirements.

While it's true that many lamps do not meet the Draft 2 specification, most incandescent A-line lamps do meet the Draft 2 specification. Indeed, the sales volume breakout for Clear vs. White (frosted, diffuse coating, etc.) in the U.S. for 15W to 150W lamps, representing almost the entire sales volume of incandescent lamps, is < 30 percent Clear vs. > 70 percent White. So, the vast majority of customers in the U.S. are expecting a luminous distribution similar to that of a frosted or diffuse white incandescent lamp when they purchase an incandescent lamp.

We have examined the luminous distribution of lamps having the two most common coil orientations (CC6 and CC8) and having a diffuse white coating. Lamps having both coil orientations meet the Draft 2 spec for luminous intensity distribution. Draft 3 allows for the wide variety of intensity distribution patterns, some of which probably would not be acceptable to the consumer.

Further, Draft 3 allows for distorted intensity distribution patterns. Certainly, these distributions would be unacceptable to most customers who buy a replacement for an incandescent omni-directional lamp.

Therefore, the proposed Draft 3 specification will allow for intensity distribution patterns that will be drastically different from that expected by most of the customers who use the LED lamp as a replacement for an incandescent lamp. The proposed specification would allow for products that would produce strong customer dissatisfaction.

To remedy this, we offer the following recommendations.

RECOMMENDATION #1

The specification should quantify a maximum allowable range of uniformity within the range of 0 to 135 degrees in order to simulate the omni-directional illumination pattern of the frosted or coated incandescent lamp that is being replaced in the majority of customer applications.

The maximum allowed non-uniformity that was proposed in Draft 2 at +/- 20 percent might be relaxed to +/- 25 percent or +/- 30 percent. But the non-uniformity must have a limit in order to prohibit wildly undesirable illumination patterns.

Next, consider the second assertion in the Cover Letter:

> Others expressed concern that the requirements would allow for no light in the 135° to 180° zone, the area around the base of the lamp, which is needed for table lamps and other applications in which the lamp is positioned base down.

This may be a valid concern, because the downward light is not enough for table lamp applications, but it is not properly addressed by the proposed specification in Draft 3. The requirement in Draft 3 that > 20 percent of the light be in the range beyond 90 degrees does not ensure that there is any light at all in the 135-180 degree zone.

Alternatively, others within our membership recommend changing "80%" to "70%" to ensure more light emitting outside of the 60-degree cone, therefore more useful light in table lamp applications. Table lamps are the most common application in consumer households and hospitality applications.

RECOMMENDATION #2

If it is determined that this second assertion is a valid concern, then a more appropriate solution would be to specify a minimum amount (e.g. 2-5 percent) of light in the 135 to 180 degree zone.

This requirement will be satisfied, almost by default, if the amount of light required is only ~ 2-5 percent of the total flux, and if the luminous intensity distribution meets the requirement of Recommendation # 1 above.

Note that the percentage of 4π steradians solid angle that is encompassed in the 135-150 degree zone is 8 percent, while the zone from 135-180 degrees represents 14 percent of 4π. So, requiring that 2 percent of the flux of the lamp be in the 135-150 degree zone, assumes that the average light flux in that zone is about ¼ of the flux level in the 0-135 degree zone.

In order to address this concern, and also to address the concern from the second assertion above that "various distributions can meet general lighting requirements", there could be a separate specification for "non-directional" lamps, rather than to allow for unacceptable distributions in the specification for "omni-directional" lamps, as proposed in Draft 3.

RECOMMENDATION #3

Provide a separate specification for "non-directional" lamps, in addition to the specifications for "directional" and "omni-directional" lamps.

The specification for the non-directional lamp need not require any light at angles > 90 degrees, since the omni-directional lamp specification will provide for light in that zone to satisfy customers having an omni-directional application.

EXAMPLE OF A SET OF SPECIFICATIONS MEETING THE ABOVE THREE RECOMMENDATIONS

For omni-directional lamps:
Products shall have an even distribution of luminous intensity within the 0 to 135 degree zone (axially symmetric, as measured in vertical planes at 0, 45 and 90 degree, see Appendix B for illustration). Luminous intensity at any angle within this zone shall not differ from the mean luminous intensity for the entire 0 to 135 degree zone by more than 25 percent. Products shall have at least 2% of the total flux in the 135 to 180 degree zone.

For non-directional lamps:

Products shall have less than 80% of the total flux in the 0^o to 60^o zone (axially symmetric, as measured in vertical planes at 0^o, 45^o and 90^o).

Lumen Maintenance

There is some confusion about this requirement. Some companies believe that the 45C requirement will limit the maximum light output of any product to its size/volume to due to the ability to dissipate heat this extreme environment. We suggest that the DOE re-evaluate the temperature specification to typical application conditions and not the extreme. To meet extreme conditions, additional technologies would need to be applied such as active cooling or higher quality die/package innovation (improved max T, higher efficacy, etc...) which will raise cost.

These companies propose the test temperature should be changed to 25C. However, the test should be performed with the lamp placed inside a confined space that emulates the condition of a lamp placed inside a glass globe luminaire.

Other companies perceive that 45C is only part of an accelerated stress test to evaluate and extrapolate the lumen maintenance. (It is our interpretation that the lamp is tested in an ambient environment of 45C, for the duration of the test period (6,000 hours). During the test period of 6,000 hours, some lamp failures may happen due to electronic component (driver) failure. So the average lumen maintenance should only be computed over the surviving lamps; meaning that perhaps more than 10 should be tested (to make sure that at the end of the test there are still 10 lamps alive).

Decorative Lamps

Decorative lamps are used for decorative purposes, and often combined with various color shades in the luminaires. There is no reason to restrict CRI to be 80.

Minimum Luminous Efficacy

Decorative lamps are typically very small, therefore getting high efficacy is very challenging. To promote the LED decorative lamp's applications and large adoption, we recommend changing

the efficacy target to minimum 30 or 35 lumens/W, which works in concert with our recommended minimum CRI of 80.

Directional Lamps

Minimum Luminous Efficacy

We recommend changing this to 35 lumens/W and 40 lumens/W rather than the 40 and 45 that are listed.

Lumen Maintenance

As noted above, there is some confusion about this requirement. Some companies believe this requirement will limit the maximum light output of any product to its size/volume to due to the ability to dissipate heat this extreme environment. These companies suggest that the DOE re-evaluate the temperature spec to typical application conditions and not the extreme. To meet extreme conditions, additional technologies would need to be applied such as active cooling or higher quality die/package innovation (improved max T, higher efficacy, etc...) which will raise cost.

Other companies perceive that the 45C is only part of an accelerated stress test to evaluate and extrapolate the lumen maintenance. (It is their interpretation that the lamp is tested in an ambient environment of 45C, for the duration of the test period (6,000 hours). During the test period of 6,000 hours, some lamp failures may happen due to electronic component (driver) failure. So the average lumen maintenance should only be computed over the surviving lamps; meaning that perhaps more than 10 should be tested (to make sure that at the end of the test there are still 10 lamps alive).

PAR Lamps and MR16 Lamps

The minimum CBCP values are much lower than typical halogen PAR and MR CBCP values. This discrepancy will likely result in dissatisfaction for end-users. These end-users have certain expectations from their experiences with halogen reflector lamps, and it would seem unfair to hold LED reflector lamps to a lower standard of CBCP performance.

Energy Star could define typical CBCP value for each level of replaced wattage, along with a minus tolerance (such as max -15 percent). We are concerned the use of an Excel spreadsheet to determine values can lead to manipulation of results.

Another company believes using the center beam intensity level to benchmark LED lamp performance against halogen lamps for directional applications is not necessarily a good approach. Instead, the performance could be measured by the total luminous flux for a given spread angle or cone, namely effective lumens. And then the efficacy could be calculated using effective lumens divided by total input electric power.

Lumen Maintenance Testing and Life Claims

Tables on Lumen Maintenance Thresholds

Please clarify - Does the DOE mean average must meet or exceed target in the table with no individual less than 3 points below target?

Some companies consider these lumen maintenance numbers to be very high. Before making any suggested changes to these numbers, these companies would like to know if the numbers factor in the potential degradation of the optics or cover lens material. If not, a proper transmittance loss of optical material might need to be considered.

On the matter of allowing longer life claims, based on longer required test periods, IES TM21 allows claims of 6 times the test period.

Option for Early Initial Qualification

3,000 Hours at 45C: We recommend changing to 40C. With CFLs, products are more similar among manufacturers. This creates a possibility for stricter accelerated life testing parameters. However, LED retrofit lamp designs vary widely, and thus, this particular parameter should be slightly relaxed in order to accommodate the range.

Average Lumen Maintenance: As above, some companies consider these lumen maintenance numbers to be very high. Do the figures include the potential degradation of the optics or cover lens material? If they do not, according to these companies, a proper transmittance loss of optical material might need to be considered. The companies also suggest that criteria need to be established for driver electronics because driver electronics have a higher probability of failure during such severe tests.

Qualification

CCT at 100 hours

All performance measurements should be done at 0 hours or at 100 hours not both. It is an undue burden to require both. We recommend 100hrs for all "Initial" performance measurements.

Independent Third Party Testing and Verification

Depending on third party labs for all performance testing will incur high costs and long lead time for manufacturers' product launches. As you know, some large companies have their own labs and recommend that DOE allow manufacturers' own NVLAP-qualified labs to provide data to qualify these products for Energy Star. Smaller companies, who do not have their own labs, favor requiring independent third-party testing for qualification. We note also that the Energy Star plans to have a robust independent third-party verification and testing program.

Thank you again for the opportunity to provide these comments. Contact Craig Updyke at cra_updyke@nema.org or 703 841 3294 with any questions.

END COMMENTS