Department of Energy
Washington, DC 20585

December 3, 2009

Dear ENERGY STAR Stakeholders:

Please find attached the final criteria for ENERGY STAR Integral LED Lamps. The Department of Energy (DOE) published the first draft of these criteria January 16, 2009, and invited stakeholder comments through February 27, 2009. DOE received 26 comment letters during the first review and comment period. The second draft was published May 19, 2009, with stakeholder comments received through June 26, 2009. Comments on draft 2 were received from 13 organizations and individuals. DOE published the third draft of these criteria September 18, 2009, and invited stakeholder comments through October 16, 2009. DOE received 7 comment letters during the review and comment period. The final version of the criteria reflects significant input from industry and the energy efficiency community.

This letter summarizes stakeholder feedback received on the third draft document, and identifies specific changes to technical requirements made in response to stakeholder feedback and/or additional technical analysis and data gathering.

SUMMARY OF COMMENTS AND DOE RESPONSES

1. Correlated Color Temperature (CCT)

Industry stakeholders supported expanding allowable nominal CCTs for non-standard lamps and lamps intended for outdoor applications to include all eight CCTs defined in ANSI C78.377[1] and adding 4200 K. Energy-efficiency program stakeholders supported limiting CCTs to 4000 K and below, but noted this creates an inconsistency with the ENERGY STAR requirements for CFLs.

DOE response: Allowable nominal CCTs remain 2700 K, 3000 K, 3500 K, and 4000 K for the following reasons:

i) The LED replacement lamp types included in the Integral LED Lamps criteria are intended to replace incandescent and halogen lamps, which have warmer color appearance.

ii) One of the key lessons learned from the market introduction of CFLs is color appearance is very important to consumers. Even today, after 20+ years of CFL promotion and product improvement, fluorescent lighting is still most often characterized as “harsh” or “cold” light.

iii) In contrast to CFL technology, luminous efficacy of cool white LEDs is higher than that of warm white models. Allowing cooler nominal CCTs risks skewing available ENERGY STAR Integral LED Lamps to high CCT models

[1] ANSI_NEMA_ANSLG C78.377-2008. American National Standard for electric lamps - Specifications for the Chromaticity of Solid State Lighting Products.

that can more easily meet the minimum efficacy requirements, leading to potential consumer dissatisfaction with these lamps.

iv) Lamps may be used in a variety of applications, both indoor and outdoor. Measures to differentiate and restrict lamps for outdoor applications would be difficult to enforce and burdensome for manufacturers.

2. Color Rendering Index (CRI)

Although industry stakeholders had cited the technical difficulty of meeting 80 CRI at warm CCTs and high efficacy levels in the Draft 2 comment period, they reversed this position in comments on Draft 3, requesting the minimum CRI be held at 80. Industry feedback further indicates today's leading warm white LEDs typically have CRI of 80. Efficiency program stakeholders supported CRI of 80 and a minimum R9 (deep red) requirement.

DOE response: DOE has revised the minimum CRI requirement to 80, a level consistent with requirements of the ENERGY STAR CFL program. The requirement for R9 value greater than 0 has also been retained from Draft 3. Although this requirement may seem low, R9 has a disproportionate effect in the color space used to calculate CRI, particularly for lamps with lower CCT. In fact, NIST researchers investigating lighting color quality point out many common light sources have negative R9 values and a 3000K tri-phosphor T8 lamp with CRI (Ra) of 85 had an R9 score of 2.

3. Omnidirectional Lamps – Luminous Intensity Distribution Requirements

As background, industry comments on Draft 2 questioned the requirement for relative uniformity throughout the 0° to 135° zone (where the lamp is positioned base up and 0° is straight down), pointing out that many incandescent A-type lamps do not meet this degree of uniformity, and that various distributions can meet general lighting requirements. An example provided was a clear incandescent lamp which would not meet the uniform intensity distribution 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. DOE sought to accommodate these concerns by defining onmidirectional lamps as all distributions having less than 80% of lumens in the 0° to 60° zone (the inverse of a European standard definition for directional lamps). This was intended to allow manufacturers greater flexibility in designing omnidirectional distributions. Draft 3 also required 20% of the light emitted to be above 90 degrees to ensure adequate coverage for base-down applications.

Industry stakeholder response to the revision in Draft 3 was quite negative, arguing that the specifications as written would lead to qualified lamps providing no light in the 60° to 90° zone. In fact, industry stakeholders pointed out that more than 70% of incandescent lamps sold in the US are frosted white and would meet the uniformity requirements described in Draft 2. These stakeholders now urged DOE to maintain the distribution requirements contained in Draft 2. Other industry stakeholders strongly recommended stricter uniformity requirements throughout the entire 0° to 180° zone so that every qualified omnidirectional lamp would be optimized for table lamp applications.

DOE response: To provide for relative uniformity similar to that of frosted incandescent lamps, and to provide for adequate downward light for base-down applications, the final criteria specify the following luminous intensity distribution requirements for omnidirectional lamps:
"Products shall have an even distribution of luminous intensity within the 0° to 135° zone (vertically axially symmetrical). Luminous intensity (candelas) at any angle within this zone shall not differ from the mean luminous intensity for the entire 0° to 135° zone by more than 20%. Also, at least 5% of total flux (lumens) must be emitted in the 135°-180° zone. Distribution shall be vertically symmetrical as measured in three vertical planes at 0°, 45°, and 90°."

4. Lumen Maintenance Testing

Industry stakeholder feedback indicated the requirement to test lamps (other than decorative lamps) at 45°C would be difficult. They suggested lumen maintenance testing be conducted for all lamps at 25°C, representing typical open air operation. Other than these comments on the required ambient temperature during lamp aging, stakeholder comments largely supported the overall approach proposed for minimum life, lumen maintenance testing and additional testing to support longer life claims. Energy-efficiency program sponsors supported full lamp testing for at least 6000 hours as well as rapid-cycle stress testing.

DOE response: Incandescent lamps are used in a range of lighting fixture types, including totally enclosed fixtures and insulated recessed downlights. As background, one of the challenges faced by integral electronically-ballasted CFLs (and shared by LEDs) is their sensitivity to heat when used in such fixtures. CFL failures and performance problems in insulated-ceiling, airtight (ICAT) recessed downlights led to the requirement for elevated temperature life testing (ETLT) for reflector CFLs participating in the ENERGY STAR CFL program. That testing requires the lamps to operate at 55°C, based on heat dissipation of a 13W CFL in an ICAT luminaire. The requirement to test integral LED lamps at 45°C was based on lamp power of approximately 10 watts used in insulated environments. However, it is recognized that lamps of different wattages and different fixture types will experience different ambient temperatures. DOE has revised this testing requirement to 45°C for lamps of 10 watts or higher. Lamps less than 10 watts will be tested at 25°C.

5. Minimum Center Beam Intensity for PAR and MR16 Lamps

Industry stakeholder comments recommended defining typical center beam candlepower (CBCP) for each replaced wattage along with a maximum -15% tolerance, stating the CBCP values required in Draft 3 are too low to ensure user satisfaction.

DOE response: The required minimum CBCP levels are intended to establish a floor for LED PAR and MR16 replacement lamps. The requirements are based on, but also recognize variability in, performance of incumbent halogen lamps. Most LED replacement lamps of these types currently do not meet the minimum requirement contained in these criteria. The required minimum CBCPs will help ensure qualified LED replacement PAR and MR16 lamps are within acceptable ranges, relative to incumbent technology.

6. Power Factor

In Draft 3, DOE revised the power factor requirement (which in earlier drafts had been 0.7 for all lamp types and wattages) to the following:

For lamp power ≤5W, no minimum power factor is required.
For lamp power >5W, power factor must be ≥ 0.7.

Citing the difficulty of achieving .7 power factor in small form factor lamps, industry stakeholders recommended the following:

< 7W	No power factor requirement
7-25W	0.6 PF
> 25W	0.7 PF

DOE response: DOE reviewed CALiPER test results for 23 LED replacement lamps ranging from 6 to 17 watts and including A-type, MR16, PAR/R20, PAR/R30, and PAR/R38. The average power factor for these lamps was 0.7, with a range of .5 to 1.0. These results indicate power factor of 0.7 is possible, even for smaller lamps. In fact, even among 36 lamps of 5 watts or less tested by CALiPER (about half of which were MR16 lamps) average power factor was 0.6. In the final criteria, DOE has maintained the Draft 3 requirements for power factor. Language addressing low voltage MR16 replacement lamps was added to the power factor requirement because the ultimate power factor depends on the transformer, not on the replacement lamp. The revised language is as follows:

For lamp power ≤5W and for low voltage lamps, no minimum power factor is required.
For lamp power >5W, power factor must be ≥ 0.70.

Note: Power factor must be measured at rated voltage.

7. Other Technical Comments

Comments were received addressing several other topics, summarized along with the DOE response below:

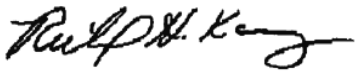
Requirement in Draft 3	Comment(s)	DOE Response
EMI/RFI: Integral LED lamps must meet the appropriate FCC requirements for consumer use (FCC 47 CFR Part 15) and/or industrial use (FCC 47 CFR Part 18).	Should reference Part 15, as Part 18 only covers radio frequency lighting devices that ionize a gas.	Revised language: Integral LED lamps must meet the appropriate FCC requirements for consumer use (FCC 47 CFR Part 15).
LED Operating Frequency: ≥ 120 Hz	May cause flickering for some people. Recommend ≥ 150 Hz	Revised language: LED Operating Frequency: ≥ 150 Hz
Rapid-Cycle Stress Testing, Laboratory Requirement: DOE CALiPER Recognized or NVLAP Accredited for LM-79-08	Reference standard is LM-65, so shouldn't the Lab requirement be NVLAP for LM-65?	Revised language: DOE CALiPER Recognized or NVLAP Accredited for LM-79 or NVLAP Accredited for LM-65-01

SCHEDULE

The effective date for the Integral LED Lamp criteria will be August 31, 2010.

DOE appreciates the on-going level of stakeholder interest in the ENERGY STAR program, and in particular, your substantive input on the integral LED lamp criteria.

Sincerely,



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