

# Laboratory versus Production SSL Metrology: Lessons and Questions from CALiPER

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CORM Conference

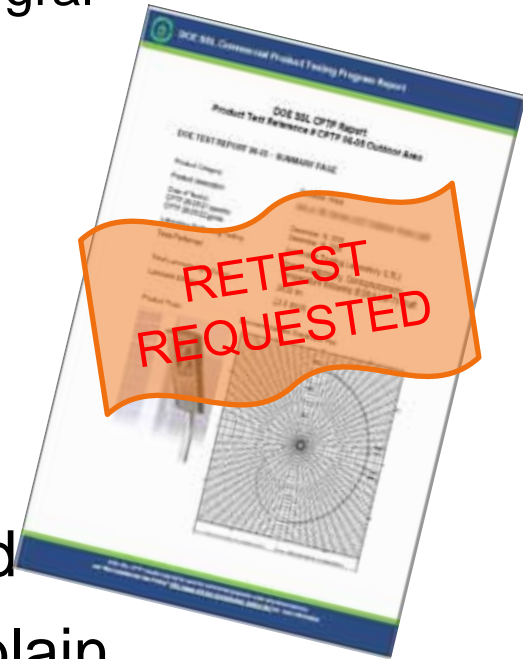
Gaithersburg, MD, May 5, 2011

# What is CALiPER Seeing?

- ▶ Wide-spread, on-going differences between CALiPER results and manufacturer claims
- ▶ Is production testing conducted?
- ▶ If so, why do results differ from laboratory testing?
- ▶ What can/should be done to improve production testing?

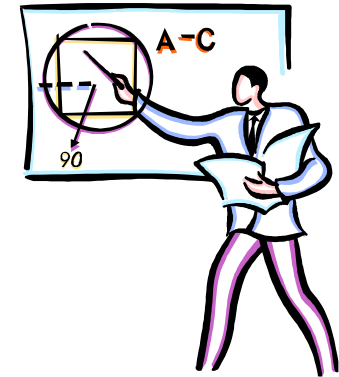
# Focus of CALiPER Testing

- ▶ Primary focus of CALiPER
  - Commercially available SSL luminaires and integral lamps
  - Anonymously purchased samples
  - LM-79 testing using qualified independent labs
  - Posting and analyzing test results
- ▶ CALiPER purchases integral products
- ▶ Differences between CALiPER testing and manufacturer claimed performance abound
- ▶ Manufacturers seek to understand and explain these differences



# Primary Explanations for Differences

- ▶ No testing conducted on integral, production products, but assumptions made based on LED device performance
- ▶ Rapid pace of technology and market evolution makes up-to-date testing and labeling a challenge
- ▶ Relative photometry, absolute photometry, and spot photometry are not comparable
- ▶ Ratings are established one way, performance is something else
- ▶ Production discrepancies—common in immature products
- ▶ Doubts about accuracy of laboratory results
- ▶ At a loss to explain...can find no reason



# Fundamental Issue: Device vs Integral Product

## ► Real example of manufacturer response:

“I received the packet of test results ...I was shocked by the lumen values reported for these lamps...

We do specify the LEDs used. We choose the highest efficacy LEDs available for our high power led lamps...

We believe the efficacy of the warm white LEDs used in the lamps tested is more than 80 lumen/watt...

We realize this does not mean the lamps achieve the same efficacy, but the CALiPER reports have them at 23 lumen/watt and 28 lumen/watt...

The difference seems far too large to be correct.”



# Lack of Understanding of LED Devices

“We will be attending the CES Show this year and are planning to show a new ~~XXXX~~'s A19 LED bulb. It has new technology that shows an increase of lumens per watt by nearly double. It is not dependant on the type of LED used.”



# Issues stemming from rapid pace of change

- ▶ Testing conducted on prototypes or early-production runs
- ▶ Coping with rapid introduction of updated versions
  - Seeking higher performance
  - Seeking lower cost
  - Coping with availability of components
- ▶ Handling labeling of updated versions
  - Existing stock in the distribution supply chain
  - Package labeling challenges (e.g. Lighting Facts label requirements)
  - Chicken & Egg time crunch for labeling (e.g., lead-time for ENERGY STAR testing)



# Variations in What is Being Tested

- ▶ Prototype or Early-Development Product Testing
  - LED Device
    - Multiple options may be employed in design phase
    - Specific bins may be used
    - Production products may draw from multiple LED vendors
  - Heat sink design, material, and/or thermal mounting
  - Power supply/driver variations
    - Operating current, voltage
    - Modulations (PWM or other)
    - Thermal communication between driver and LED module
  - Optics (materials, positioning, coatings, mounting)
  - Assembled product (adhesives, coatings, thermal interactions, positioning)



# How Ratings & Published Values Are Established

- ▶ Test to establish and validate ratings based on IEC and ANSI specified methods and conditions
  - But, LM test methods are guidelines, not entirely prescriptive
  - LM's say how to measure
  - LM's do not say how to define rated performance
- ▶ Laboratory conditions vs. field conditions
  - Similarity to field conditions may be more for some LM's (and some light sources than others)
    - CFL lamps rated at 35C, absolute tested in fixture at 25C
  - Wattage (and voltage and current) may vary under reference conditions
- ▶ Rating determination not defined for SSL
  - Number of samples to use, values to apply as rating, handling evolution



# Absolute vs. Relative vs. Spot Photometry

- ▶ Photometry in production does not necessarily follow standardized methodologies
- ▶ Modified spot or sphere testing may be used
  - For example, rapid 2 pi-style sphere check
  - How do you correlate and give meaning to results?
- ▶ Level playing field issue
  - Benchmark products use relative photometry
  - Some SSL advocates insist on perceived brightness
  - Spot illuminance is cheaper to conduct



Results can be used to monitor quality, as relative measures, but must be calibrated and correlated to standardized photometry to be used as any indication of performance.

# Typical CALiPER Example

CFL



Halogen



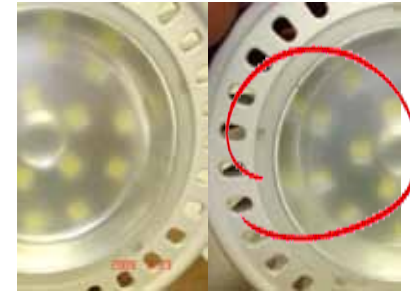
LED



- ▶ Three versions of the same product
- ▶ Manufacturer brochure 'output lumens' appear to correspond to the lamp rating for each light source
- ▶ The manufacturer IES files then indicate a 'fixture efficiency' to apply to the lamp rating
- ▶ Performance results from manufacturer do not correspond with CALiPER absolute photometry

# Production & Post-Production Discrepancies

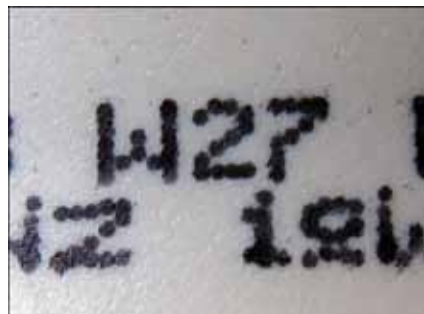
- ▶ Consistency
  - Depends on volume, throughput, time frame
- ▶ Labeling challenges
  - Erroneous CCTs
  - Handling multiple SKUs
- ▶ Physical, assembly defects
- ▶ Workmanship, shipping, handling



Shifting plate reduces light output



Clouding



4200K lamp, Stamped and mislabeled as 2700K



Pins repeatedly bent during shipping



Repeated samples arrive damaged

# Doubt about accuracy of laboratory results

- ▶ *“It might be prudent to send one of the bulbs to another lab or any solution you suggest...we have no other ~~XXXX~~ with a similar problem.”*
  - CALiPER retesting showed no difference
- ▶ *“To address issues, conduct absolute and relative photometry at ~~XXXX~~, then send exact same luminaire to ~~XXXX~~ and duplicate the tests”*
  - CALiPER retesting in process
- ▶ Operating levels
  - When ~~XXXX~~ tested the product, it measured 19.3W, when ~~XXXX~~ tested the product, it measured 16.0W.
  - The new version has a modified the circuit and does draw 19W, confirmed by ~~XXXX~~ LM79 testing on the new series.
- ▶ Measured chromaticity values

# Unbelievable...at a loss...can find no reason

- “After rechecking with our manufacturer and our own internal tests on over 600 bulbs there is a variation in the test results CALiPER testing we cannot replicate...
- We have no reports of degraded lumen output...
- **We cannot come up with a reason why the two bulbs tested have 25% less lumen output.”**



# At a loss...Does Not Make Sense!

“Attached is a confidential chromaticity chart from ~~XXXX~~. Please notice the chromaticity of the two bulbs on the attached document checked by the Round 8 lab. The page shows the normal color range of c1, c2 model of the ~~XXXX~~ bulb and the location of the color tested by the lab. This ~~XXXX~~ bulb does not normally produce this blue color of light and the odds of finding this color difference in both tested bulbs does not make sense with the information we have...”



# For SSL Luminaire and Integral Lamp Testing

- ▶ Primary issues between laboratory and production testing
  - Is production testing actually conducted?
  - What is being tested?
  - How are the test results used?
  - Production testing is relative, controlling quality, not to be confused with absolute photometry of final products
- ▶ How are consistent production quality control practices developed and instilled in a new, rapidly evolving field?
- ▶ Most issues do not appear to be tied to measurement methodologies
  - But, proficiency testing needs to be defined and conducted to reduce doubts about testing process
  - Consistent methods needed for verifying results for each type of measurement methodology across labs and in production setting





# THANK YOU

▶ Mia Paget, PNNL



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