ENERGY STAR® Displays: DOE Testing Results

April 19, 2012
DOE Displays Team
Introduction

- Testing performed to investigate:
  - Test method repeatability
  - Impact of vertical angle on power consumption at different lux
  - Impact of horizontal angle on power consumption at different lux
  - Impact of distance on power consumption at different lux
  - Impact of wattage/lumen output on power consumption at different lux
  - Direct vs. diffuse incident light
Direct Incident Light Setup

Top View

980 ± 5% Lumens Flood Reflector Lamp

Voltage Regulator

5'

90

Light Sensor

D₁ ≤ 2.5'

D₂ ≤ 2.5'

D₁ = D₂ with respect to vertical reference plane
Direct Incident Light Setup

Side View

980 ± 5%
Lumens Flood
Reflector Lamp

D_1 = D_2 with respect to vertical reference plane
H_1 = H_2 with respect to floor
Measuring and Adjusting Illuminance
All Test Setups

1. Hold illuminance meter directly over light sensor, flush with face of UUT, and facing light source

2. Adjust voltage to light source until target illuminance achieved

3. Remove illuminance meter and proceed with power measurement

980 ± 5% Lumens Flood Reflector Lamp
Repeatability Testing – UUT 1

Repeatability Testing (UUT 1)

- **Run 1**: Baseline
- **Run 2**: Move & Replace Display
- **Run 3**: Exact Repeat of Run 2
- **Run 4**: Move & Replace Light Source

Power (W) vs Illuminance (lux) graph.
Repeatability Testing – UUT 2

Repeatability Testing (UUT 2)

Power (watts)

Illuminance (lux)

Run 1
Run 2
Run 3
## Repeatability Testing Variation
### Average Power and Standard Deviation

<table>
<thead>
<tr>
<th>Illuminance (lux)</th>
<th>UUT 1 (Direct Light)</th>
<th>UUT 2 (Direct Light)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_{AVG}$</td>
<td>COV (%)</td>
</tr>
<tr>
<td>10</td>
<td>45.8</td>
<td>0.6%</td>
</tr>
<tr>
<td>35</td>
<td>57.6</td>
<td>0.4%</td>
</tr>
<tr>
<td>50</td>
<td>63.5</td>
<td>1.5%</td>
</tr>
<tr>
<td>80</td>
<td>75.5</td>
<td>0.4%</td>
</tr>
<tr>
<td>100</td>
<td>82.5</td>
<td>1.4%</td>
</tr>
<tr>
<td>300</td>
<td>107.6</td>
<td>0.1%</td>
</tr>
<tr>
<td>500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Light Source – Bulb Type

45 W Halogen vs. 100 W Equivalent Halogen (UUT 1)
Light Source – Alignment
Vertical Angle With Respect to Light Sensor

Light Source Vertical Angle Testing (0 vs. 45)

- 0 (UUT 1)
- 45 (UUT 1)
- 0 (UUT 2)
- 45 (UUT 2)
Light Source – Alignment
Horizontal Angle With Respect To Light Sensor

Light Source Horizontal Angle Testing (UUT 1)
Light Source – Distance

Light Source Distance Variation (UUT 1)

- Average Power (W)
- Illuminance (lux)
- Distance variations: 1 ft, 2 ft, 3 ft, 4 ft, 5 ft, 7.5 ft, 10 ft

Graph showing the relationship between illuminance and average power for different light source distances.
Light Source – Distance

Light Source Distance Variation (UUT 1)
Light Source – Type of Incident Light
Direct vs. Diffuse

• Compared direct incident light to five different setups using a diffusing medium
• Diffuse setup diagrams provided in slides 15-19 (for illustrative purposes only)
**Light Source – Type of Incident Light**

**Diffuse Setup #1 (Transmission) – Side View**

- **Light Source**: 980 ± 5% Lumens Flood Reflector Lamp
- **Diffusing Sheet**: 4’x4’ Nylon Diffusing Sheet
- **Sensor**: Varied to Adjust Illuminance
- **UUT**: Vertical Reference Plane
Light Source – Type of Incident Light
Diffuse Setup #2 (Transmission) – Side View

980 ± 5%
Lumens Flood Reflector Lamp

4’x4’ Nylon Diffusing Sheet
Varied to adjust illuminance

1’ (fixed)

UUT
Light Sensor

90

Vertical Reference Plane
Light Source – Type of Incident Light
Diffuse Setup #3 (Transmission) – Side View

- Type of Incident Light
- Side View
- UUT
- Vertical Reference Plane

980 ± 5%
Lumens Flood Reflector Lamp

Varied to adjust illuminance

Three 4’x4’ Nylon Diffusing Sheets

6” and 2’
(fixed)

Light Sensor

90
Light Source – Type of Incident Light
Diffuse Setup #4 (Reflection) – Side View

- 4’x4’ Nylon Diffusing Sheet
- Varied to adjust illuminance
- 6” (fixed)
- UUT
- 980 ± 5% Lumens Flood Reflector Lamp
- Vertical Reference Plane

90°
Light Source – Type of Incident Light
Diffuse Setup #5 (Transmission) – Side View

- **Diffusing Apparatus:**
  - 4”-to-3” reducer connected to 3”-to-1.5” reducer
  - Three nylon sheets placed between reducers as diffusing medium

- 50 W halogen desk lamp used as light source (100 W-equivalent not available)

- Illuminance measured and set at output of apparatus

- Apparatus placed flush to face of UUT for testing
Light Source – Type of Incident Light
Direct vs. Diffuse – UUT 1

Direct vs. Diffuse (UUT 1)

- Direct Light
- Diffuse #1 (Transmitted)
- Diffuse #2 (Transmitted)
- Diffuse #3 (Transmitted)
- Diffuse #4 (Reflected)
- Diffuse #5 (Transmitted)
## Repeatability Testing Variation

Direct Light vs. Diffuse Setup #5 (UUT 1)

Average Power and Standard Deviation

<table>
<thead>
<tr>
<th>Illuminance (lux)</th>
<th>Direct Light UUT 1</th>
<th>Diffuse Setup #5 UUT 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$P_{AVG}$</td>
<td>COV (%)</td>
</tr>
<tr>
<td>10</td>
<td>45.8</td>
<td>0.6%</td>
</tr>
<tr>
<td>35</td>
<td>57.6</td>
<td>0.4%</td>
</tr>
<tr>
<td>50</td>
<td>63.5</td>
<td>1.5%</td>
</tr>
<tr>
<td>80</td>
<td>75.5</td>
<td>0.4%</td>
</tr>
<tr>
<td>100</td>
<td>82.5</td>
<td>1.4%</td>
</tr>
<tr>
<td>300</td>
<td>107.6</td>
<td>0.1%</td>
</tr>
</tbody>
</table>
Light Source – Type of Incident Light

Direct vs. Diffuse – UUT 2

Direct vs. Diffuse Testing (UUT 2)

- **Average Power (W)** vs. **Illuminance (Lux)**

- **Direct Light**
- **Diffuse Setup #3**
  (2 feet from sensor)