Durability Testing for ENERGY STAR® Residential Light Fixtures

Roundtable Meeting
Dallas Trademart
June 23, 2003
Overview

- Project Goals
- Roundtable Summaries
- Methodology
  - Temperature Test
  - Stress Test
  - Voltage Test
- Results
- Conclusions/Recommendations
Project Goals

- Investigate possible causes of premature failures with ENERGY STAR® fixtures
- Develop test method to minimize premature failures, based on investigation
Roundtable Recommendations

- Elevated temperatures inside the fixtures are the most likely cause of premature failures
  - Focus on highly enclosed fixtures
- “Weed out” lesser quality components that are incompatible or do not meet ANSI specs by stress testing
- Measure impact of voltage variation
Temperature Test

- **Purpose**
  - Sample actual temperature conditions in operating fixtures
  - Develop test procedure for manufacturers to follow before ENERGY STAR approval
Temperature Test

- Sample selection
  - ENERGY STAR products
  - Recessed
  - Ceiling-mounted
  - Magnetic ballasts
  - Electronic ballasts
Temperature Test

- **Selection of fixture types**
  - Non-IC recessed and surface mounted fixtures

- **Sample quantity**
  - One from each fixture type and model

- **Testing location**
  - Ambient room temperature 25°C ±5°C
Temperature Test

- **Fixture characteristics**
  - Total samples = 29
    - Ceiling-mounted = 22
      - Magnetic ballasts = 12
      - Electronic ballasts = 10
    - Recessed = 7
      - All had electronic ballasts
Temperature Test Method

- Apparatus
  - Follow UL 1598, *UL Standard for Safety of Luminaires*
  - Thermocouple locations differ from ballast to ballast
Temperature Test Method

- Apparatus examples

Temperature Test Method

- Apparatus examples


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Temperature Test Method

- Thermocouple locations

![Diagram of thermocouple locations](image)

Caption: Courtesy: Robertson, Magnetek/Universal and Advance Transformer

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Temperature Test Method

- **Procedure**
  - Ballast manufacturer indicates maximum allowable temperature
    - If not cited, assume 65°C
  - Stabilize temperature for 7.5 hours minimum
Temperature Test Results

- Percentage exceeding allowable ballast operating case

<table>
<thead>
<tr>
<th>Fixture Type</th>
<th>&lt;64°C</th>
<th>65-74°C</th>
<th>75-89°C</th>
<th>90°C+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling mounted fixture, magnetic ballast (n=12)</td>
<td>8%</td>
<td>8%</td>
<td>25%</td>
<td>58%</td>
</tr>
<tr>
<td>Ceiling mounted fixture, electronic ballast (n=10)</td>
<td>10%</td>
<td>40%</td>
<td>40%</td>
<td>10%</td>
</tr>
<tr>
<td>Recessed fixture, electronic ballast (n=7)</td>
<td>71%</td>
<td>14%</td>
<td>0%</td>
<td>14%</td>
</tr>
</tbody>
</table>
Temperature Test Results

- Ceiling mounted fixtures with electronic ballasts
Temperature Test Results

- Ceiling mounted fixtures with magnetic ballasts

![Graph showing ballast temperature results](image-url)
Temperature Test Results

- Recessed fixtures with electronic ballasts
## Temperature Test Results

- As maximum allowable ballast operating case temperature becomes more strict, percentage of samples exceeding limit

<table>
<thead>
<tr>
<th></th>
<th>90°C+</th>
<th>75°C</th>
<th>65°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling mounted fixture, magnetic ballast</td>
<td>58%</td>
<td>83%</td>
<td>92%</td>
</tr>
<tr>
<td>Ceiling mounted fixture, electronic ballast</td>
<td>10%</td>
<td>50%</td>
<td>90%</td>
</tr>
<tr>
<td>Recessed fixture, electronic ballast</td>
<td>14%</td>
<td>14%</td>
<td>29%</td>
</tr>
</tbody>
</table>
Stress Test

- **Purpose**
  - Conduct a rapid-cycle test to stress the lamp/ballast system
  - Quickly identify any starting or operating characteristics of the ballast that may damage the lamps
  - Determine failures caused by substandard components or lamp/ballast incompatibility
Stress Test

- Sample selection
  - Wide wattage range
    - 13W CFL to high-wattage Circline® lamps
  - Not based on ANSI or IEC standards, price, nor potential quality indicator
Stress Test

- Fixture characteristics
  - Nine lamp/ballast products selected for test
  - Six samples of each product
Stress Test

- **Setup**
  - Remove lamps and ballasts from fixtures; place in racks in a base-up position
  - Regulate voltage to 120 V ±0.5%
  - Regulate temperature in lab to 25°C ±10°C
  - Lamps “seasoned” for 100 hours before test start
Stress Test

- **Procedure**
  - Rapid-cycle test of 5 minutes on/5 minutes off
    - Computer-controlled and monitored
  - Cycle operation until failure
  - Manually turn off lamps not failing by April 20, 2003
Stress Test Results

- Majority of products had at least 32,000 starts
- Two products had premature failure
  - Neither achieved 10,000 starts
Voltage Test

- Purpose
  - Measure impact of high and low supply voltage on life of typical ENERGY STAR fixtures
  - Concentrate efforts on constant over- or under-voltage conditions
Voltage Test

Sample selection

• Common lamp wattages recommended by ICF Consulting
  ▪ 13W twin-tube and double twin-tube lamps
  ▪ 30W Circline lamps
  ▪ 40W double-Circline lamps

• All products electronically ballasted

• Two examples in each category, six samples of each
Voltage Test

- Setup
  - Use 104 V and 130 V as residential extremes
  - Use 2 samples for under-voltage; 2 samples for over-voltage; 2 samples as control
Voltage Test

**Procedure**
- Continual operation at constant under- or over-voltage conditions
  - Constant power used to eliminate switching as potential failure cause
- Daily monitoring to note failures
  - Replace lamps as necessary to continue ballast tests
Voltage Test Results

- After eight weeks of constant operation, no failures occurred
  - Neither lamp nor ballast failure
- After an additional three weeks at greater voltage extremes (84 V and 156 V), still no failures occurred
Conclusions/recommendations

- Temperature test recommendation
  - Adopt LRC’s proposed test method based on pilot testing
    - Maximum allowable temperature and thermal probe location to be determined by ballast manufacturer
Conclusions/recommendations

- Temperature test recommendation
  - Documentation
    - Photographs of tested fixtures mounted in/on test apparatus
    - Ballast documentation from manufacturer for location and max. performance temperature
    - Temperature recorded at test start and after 7.5 hours of stabilization
Conclusions/recommendations

- **Stress test conclusion**
  - Studies inconclusive
    - Lamp/ballast incompatibility beyond ANSI compliance must be investigated

- **Stress test recommendation**
  - ANSI compliance as interim step
  - Further testing is warranted
Conclusions/recommendations

- Voltage test conclusion
  - Voltage alone does not appear to be a cause of premature failure; no requirements beyond ANSI standard line voltage ranges

- Voltage test recommendation
  - Since transient protection is already required by the ENERGY STAR specification, no additional requirements are necessary until test for interaction with other factors is conducted
Next Steps

- Further investigate mechanisms through which temperature may be involved in premature failure
- Determine acceptable target field failure rate/return rate for ENERGY STAR residential fixtures
Next Steps

- Test for interaction ("doe")
  - Temperature vs. voltage
  - Temperature vs. stress
  - Voltage vs. stress
  - Temperature vs. voltage vs. stress
Thank you.