Lifetime Test - a Quality Requirement

FORTALECIMIENTO DE ESTÁNDARES DE EFICIENCIA ENERGÉTICA EN ILUMINACIÓN
Primera Reunión y Taller Presencial del Grupo Técnico de Eficiencia Energética (GTEE)

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Table of Contents

Importance of LED Lifetime

- Consumers need an indication of product lifetime – the median time to failure

- Lifetime is a critical factor in a purchasing decision, along with price and running cost (i.e., energy savings)

There are two failure modes for LED lamps:

1) **Parametric** (reduced light output)
    - Lack of a useful level of light output – lumen maintenance
    - Change in the color of light produced – color maintenance
    - Visible intermittence of light output – flicker

2) **Catastrophic** (failure to produce light)
    - Lamp no longer produces light

IEC 62612, IEC 62717 Endurance Tests

1. Accelerated operational life (i.e. extreme conditions)
    - 10°C above maximum rated operating temperature
    - ON continuously
    - 1000 hours
2. Ambient temperature cycling (i.e. Max rated)
    - -10°C (1h hold) transition for 1h to 40°C (1h hold)
    - ON (34 min): OFF (34 min)
    - 250 cycles (1000 hours)
3. Supply switching (i.e. Typical)
    - 25°C ambient temperature
    - ON (30s): OFF (30s)
    - # cycle equals half the hours of rated life

IEC Endurance Tests – Equipment Required

Accelerated aging and temperature cycling tests

- Require a thermal test chamber to control/cycle the ambient conditions
- Expensive to test - many labs do not have the test chambers
- Limited capacity in the test chamber for multiple models/samples to be tested
- Thermal test chambers are used for testing emergency lighting products. Limited availability for testing general lighting products

IEC Endurance Tests – Switching On-Off

IEC rapid switching test on 20 models

- Testing on 20 different lamps, n=5 units of each (100 lamps total)
- Switching on/off 30s on / 30s off
- No units failed
- Findings confirmed industry experience with the outcomes from the rapid switching cycle test
  - Lack of thermal stresses

Lumen Maintenance Test – 6000 hours

Current Ecodesign requirements for CFL and LED:

- Non-directional CFL – at 6000 hours, has survival, lumen maintenance and switching cycles (244/2009)
- LED lamps – at 6000 hours, also has survival, lumen maintenance and switching cycles (1194/2012)

However, 6000 hours is >8 months. This can:

- Delay new products being introduced to the market
- Limit Market Surveillance (i.e., product shelf-life only 2-3 years, so non-compliant product may no longer be sold)

Needs something shorter, however if its too short there's too much uncertainty and it won't protect users

Table of Contents

EEPliant published a Final Report in Dec 2017

- EEPliant used long-duration switching cycles of 2h45m on / 15m off. This was found to be more effective than short (30 second on/off) switching
- The EEPliant final report recommends (p.22-23):

Making lifetime requirements for lamps more effective

- Time period for testing of life time parameters

Life time requirements for lamps are an essential part of the ecodesign legislation. However, the current criteria require a very long testing period of 6000 hours. Typically, LED lamp models have been sold out by the time the lab testing is completed. Thus, despite the extensive effort put into testing, the options for enforcement measures are limited. Therefore, it is recommended to shorten the period for lifetime testing to a maximum of 3000 hours - combined with the use of enforced temperature stress regimes or similar approaches that accelerate the aging of lamps[12].

- Including switching cycles in life time testing

Some screening tests supported the view that the switching of lamps at high frequency does not have a significant impact on lamp life. However, there are indications that switching combined with typical warming and cooling cycles may have a significant impact. It is therefore recommended to include switching in the lifetime testing. Switching cycles should be specified in a way that allows typical warming and cooling cycles for the lamps.

New Test: Functionality after endurance testing

- Samples of 3 or 10 units
- Normal laboratory conditions – no special temp chambers
- Real-life scenario of 2.5h on / 0.5h off
  - Stresses electronics: line-voltage capacitor can saturate and fully discharge each cycle; electronics heat and cool each cycle
- 1200 switching cycles – 3600 hour test
- Combines switching cycle and lumen maintenance – lower burden on technician (cheaper for market surveillance)
- Failures can occur due driver failure (catastrophic) or lumen depreciation (parametric)
- Equation which defines the minimum rated lumen maintenance based on the lifetime declaration

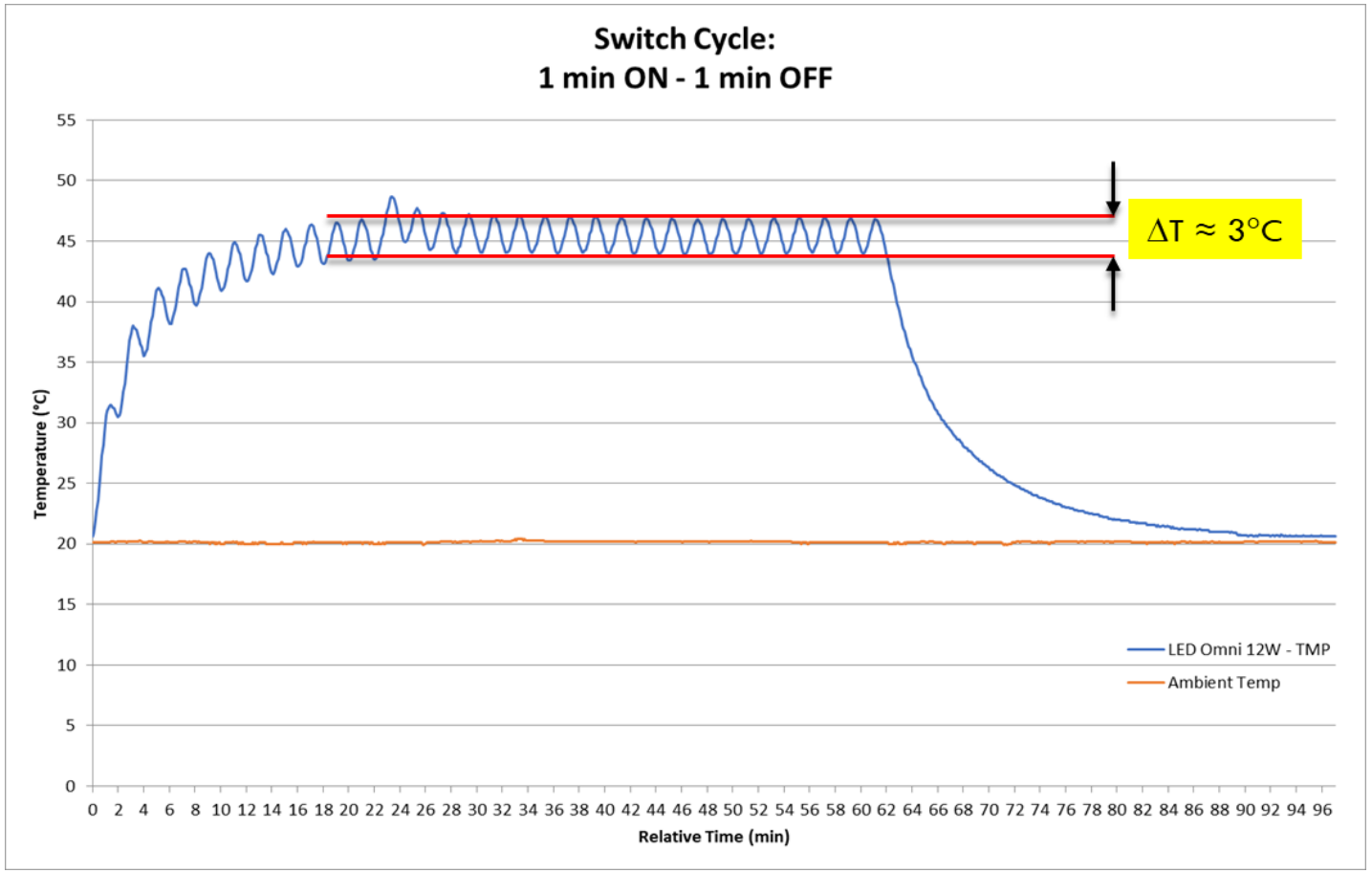
Lumen Maintenance Factor

- The lumen maintenance factor X_{LMF}% after endurance testing shall be at least $X_{LMF,MIN}$% calculated as follows:

$$X_{LMF,MIN}\% = 100 \times e^{\frac{(3000 \times \ln(0.7))}{L_{70}}}$$

- where L_{70} is the declared $L_{70}B_{50}$ lifetime (in hours)
- Upper limit for $X_{LMF,MIN}$%: the calculated required lumen maintenance of the sample shall not exceed 96.0% (i.e., $X_{LMF,MIN} \leq 96.0$ %)
  - 26,000 hours of rated life: higher is 96.0%; lower is calculated %

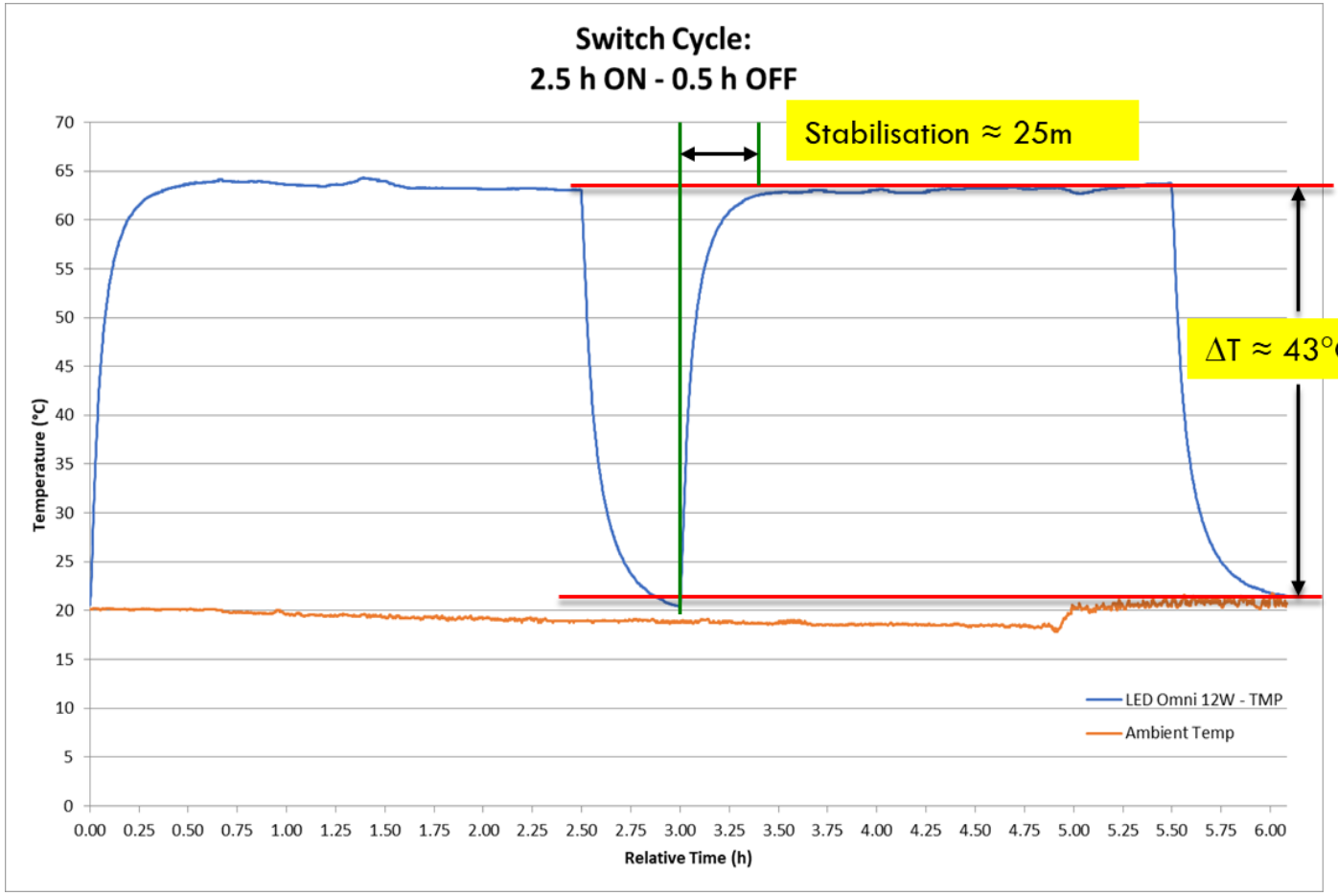
Effects of Switching Cycles on Temperature (1 of 2)



Power: 12W
Weight: 65g

Temperature measurements of the LED chips, 1min on / 1min off

Effects of Switching Cycles on Temperature (2 of 2)



Power: 12W
Weight: 65g

Temperature measurements of the LED chips, 2.5h on / 0.5h off

Table of Contents

Lamps Tested in Sweden (3600h test)

- Fifteen (15) different models, 46 lamps in total
- Switching cycle failures:
  - Model 2 – Sample 10 – failure at 2088 hours testing
  - Model 2 – Sample 11 – failure at 2928 hours testing
  - Model 13 – Sample 44 – failure at 1008 hours testing
- Lumen maintenance failures on eight of the models tested: Models 3, 4, 6, 7, 10, 11, 14 and 15.

Lamps that failed on lumen maintenance

Model	SEA ID	Watts	Declared lumens	Measured lm (100 h)	Measured lm (3600 h)	Remaining flux
3	2696-1	10	806	762,7	480,8	63%
	2696-2	10	806	760,4	466,4	61%
	2696-3	10	806	759,3	483,6	64%
4	2720-2	4	400	404,2	234,2	58%
	2720-3	4	400	385,3	233,0	60%
6	2712-1	6	420	318,9	179,5	56%
	2712-2	6	420	308,9		
7	2689-1	6	480	613,5	389,8	64%
	2689-2	6	480	601,9	379,4	63%
10	2695-2	10	800	788,2	463,2	59%
	2695-3	10	800	820,0	508,4	62%
11	2710-1	6	600	665,6	355,2	53%
	2710-2	6	600	622,8	351,0	56%
14	3102-2	3	600	613,0	402,8	66%
15	2760-1	6.3	400	434,4	266,4	61%

Lamps tested in Australia

- Eleven LED lamp models were tested in two ways:
  1. 20 models x 5 samples tested to switching 30 second on, 30 second off (part of IEC 62612 requirements) – none of the 100 samples failed this test
  2. 11 models x 4 or 5 samples were tested by 3600h test
     - Two models failed:
       - 5/5 samples of model A
       - 3/4 samples of model G
     - Three models failed on lumen maintenance, and two probably failed but no declared lifetime

Lamps that failed on switching and lumen maintenance

Model	2.5h ON / 0.5 OFF (3000hr)		
	Failures / Total	Average Lumen Maintenance	Required Minimum
A	5/5	na	95.8%
B	0/5	103.0%	93.1%
C	0/5	89.1%	93.1%
D	0/5	89.4%	95.8%
E	0/5	114.7%	93.1%
F	0/5	98.7%	94.8%
G	3/4	107.2%	95.8%
H	0/4	65.8%	no claim
I	0/4	95.9%	96.5%
J (linear)	0/5	93.9%	no claim
K (linear)	0/5	93.2%	no claim

Lifetime and Endurance Test Proposal

ANNEX B – ENDURANCE TEST SEQUENCE

Light sources shall undergo endurance testing to verify their luminous flux maintenance factor and survival factor. This endurance testing consists of the test method outlined below. The endurance test for LED and OLED light sources shall be conducted as follows:

B.1 AMBIENT CONDITIONS AND TEST SETUP:

B.1.1 The switching cycles are to be conducted in a room with an ambient temperature of 25 ±10 °C and an average air velocity of less than 0.2 m/s;

B.1.2 The switching cycles on the sample shall be conducted in free air in a vertical base-up position. However, if a supplier has declared the light source is suitable for use in a specific orientation only, then the sample shall be mounted in that orientation;

B.1.3 The applied voltage during the switching cycles shall have a tolerance within 2 %. The total harmonic content of the supply voltage shall not exceed 3 %. Standards provide guidance on the supply voltage source.

B.2 ENDURANCE TEST METHOD.

B.2.1 Initial flux measurement: measure the luminous flux of the light source prior to starting the endurance test switching cycle;

B.2.2 Switching cycles: operate the light source for 1200 cycles of repeated, continuous switching cycles without interruption. One complete switching cycle consists of 150 minutes of the light source switched ON at full power followed by 30 minutes of the light source switched OFF. The hours of operation recorded (i.e., 3000 hours) include only the periods of the switching cycle when the light source was switched ON, i.e. the total test time is 3600 hours;

B.2.3 Final flux measurement: at the end of the 1200 switching cycles, note if any lamps have failed (see 'Survival Factor' requirements in Annex IV Table 6) and measure the luminous flux of the light sources that have not failed;

B.2.4 For each of the units in the sample which have not failed, divide the measured final flux by the measured initial flux. Average the resulting values over all the units that did not fail to compute the determined value for the luminous flux maintenance factor X_{LMF}%.

- Adopted in Europe
- Proposed in South Africa

Table of Contents

Points for Discussion

- What is the experience of the TC with lifetime testing?

- Which lifetime test is appropriate for this region?

Thank you, any questions?

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