PLATFORM OMGEVINGSTECHNOLOGIE
25 november 2015, Leusden

Het voorspellen van de levensduur van LED verlichting met gebruik van omgevingstesten

En enkele voorbeelden van faal mechanismen

Boudewijn Jacobs
Philips Lighting
25 November 2015

innovation + you

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Toename in foutmodes

Light out due to:
1. Rain
2. No wood

Light out due to:
1. Rain
2. Wind
3. No candle

Light out due to:
1. Broken glass
2. Broken casing
3. EMS / ESD
4. Electrical short
5. Deterioration
6. Gas leakage
7. Mishandling

Light out due to:
1. Die Crack
2. Delamination
3. Software failures
4. ...

> 30 known FM's,
See next slide

Onze groep houdt zich o.a. bezig met:

1. Failure Mode and Mechanisms Investigation

- Color and lumen maintenance
- Catastrophic failures
- Accelerated testing
- Reliability of connected systems
- Development and deployment of release procedures
- Supporting businesses during development and service agreements

2. Reliability Lab ISO17025 compliance

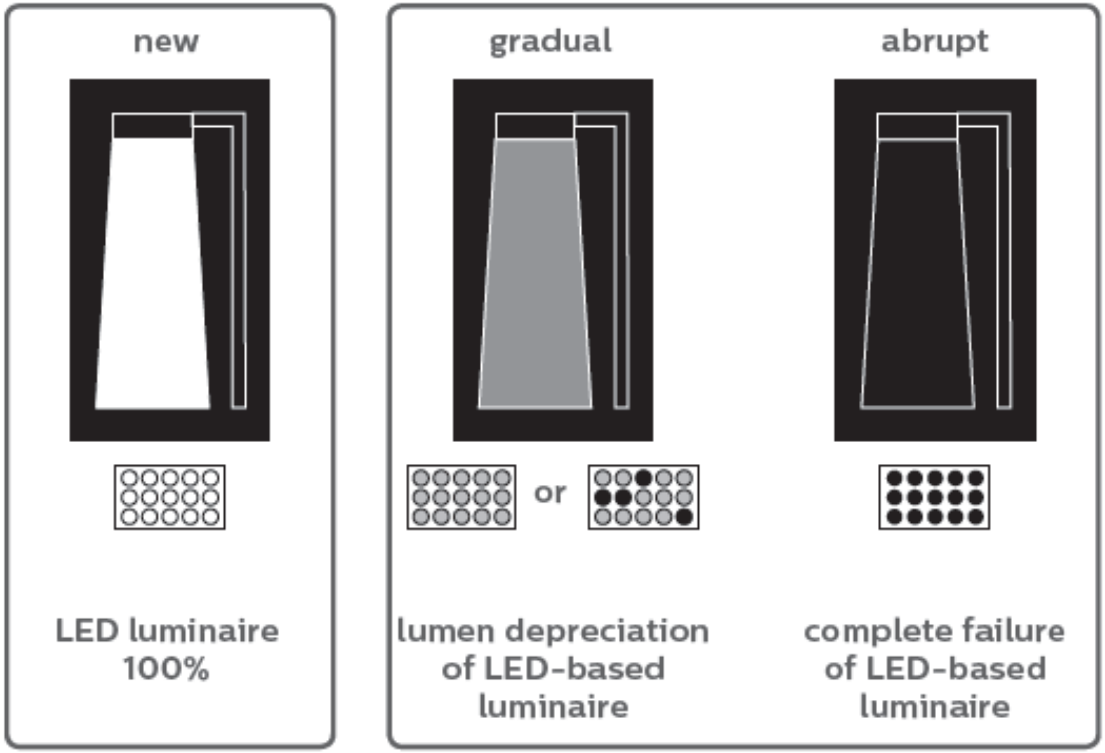
- Internal certification program
- Expanding in 2016 EMEA & NA
- 35 testing locations in scope

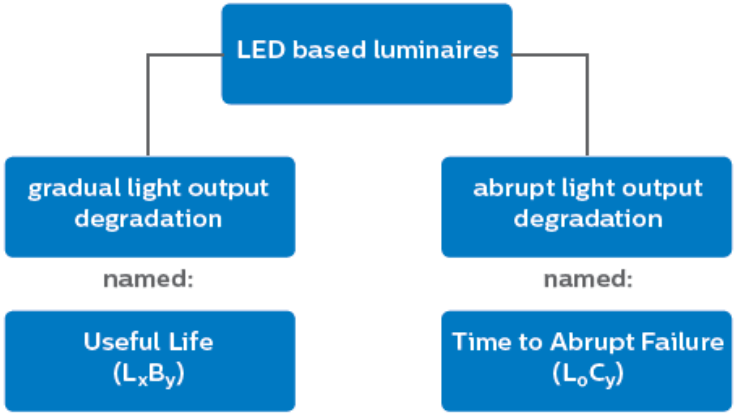
# Tickets	Internal Certification Level
< 60	Reliability lab under witness of Dev Q
60 - 80	Reliability lab under supervision of Dev Q
80 -100	Recognized reliability lab
> 100	Expert reliability lab

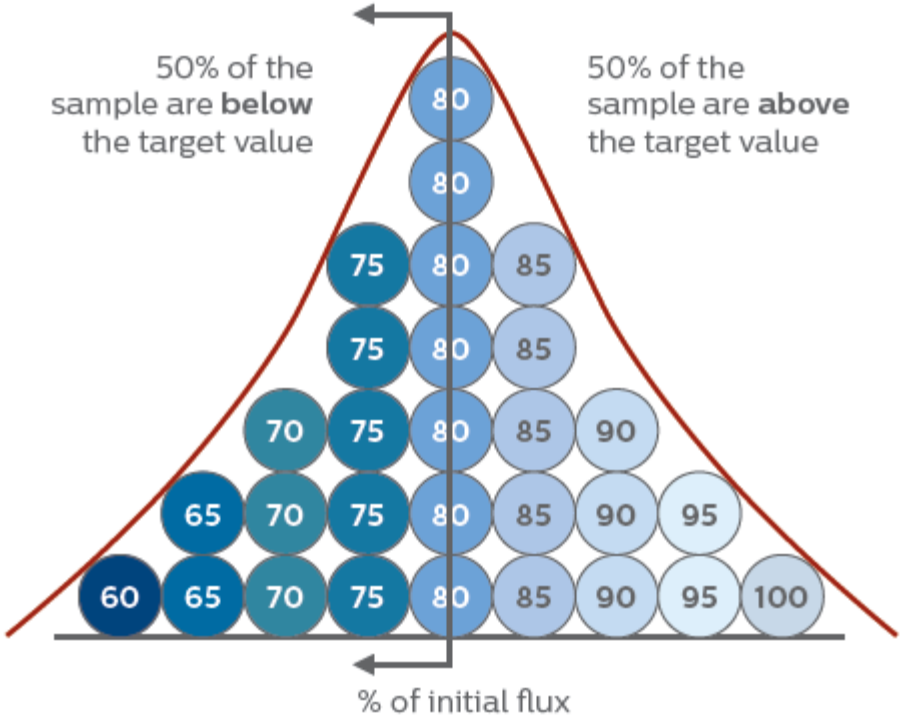
3. System Reliability Tool

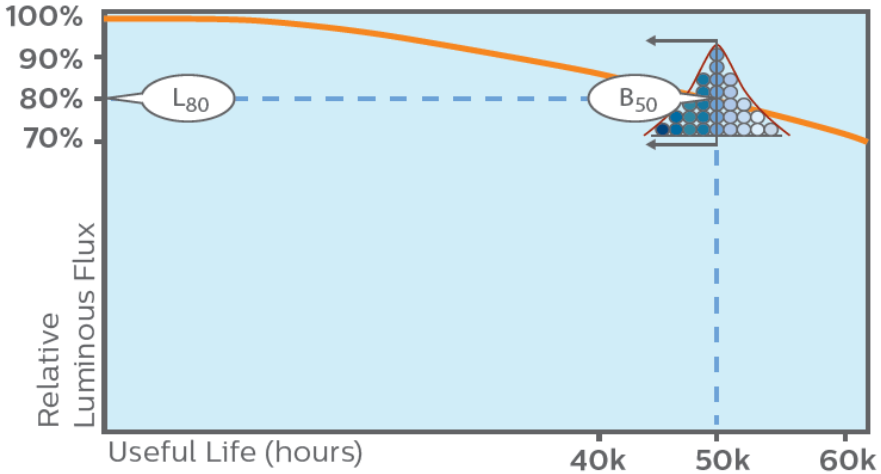
- Single source for reliability calculations, >250 users
- Covering 90% of all our LED-based product developments
- Filled with up-to-date reliability models for all components, e.g. LEDs, drivers, controls, etc.

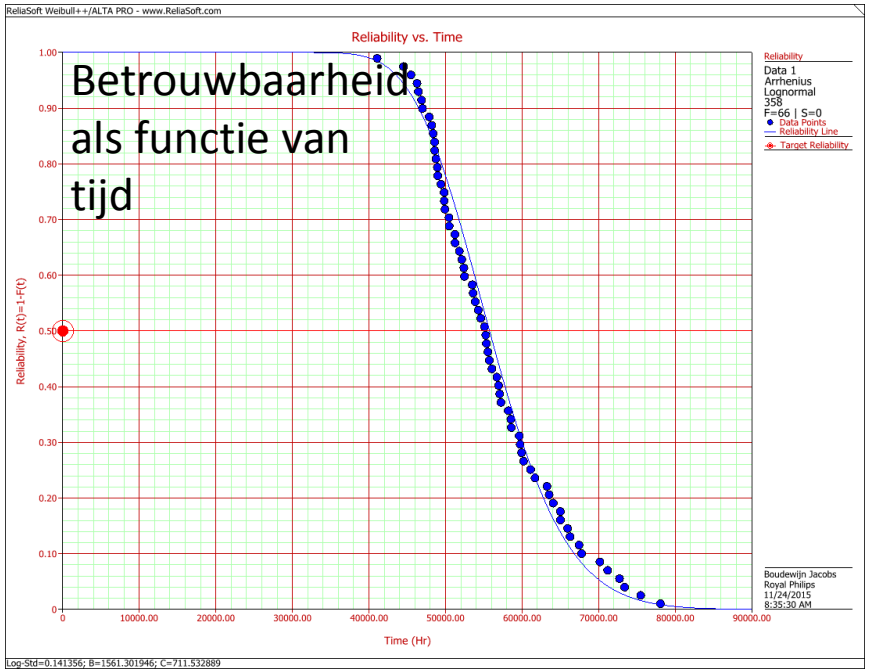
Hoe definieren we de levensduur van LED verlichting ?

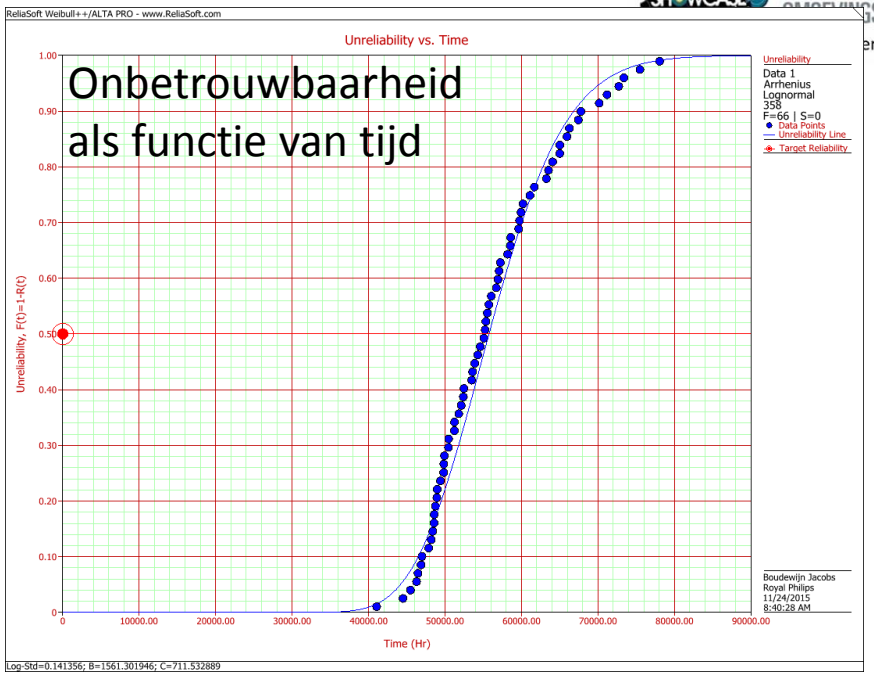





50% of the sample are **below** the target value
50% of the sample are **above** the target value
80
80
75 80 85
75 80 85
70 75 80 85 90
65 70 75 80 85 90 95
60 65 70 75 80 85 90 95 100
% of initial flux


100%
90%
80%
70%
L_{80}
B_{50}
Relative Luminous Flux
Useful Life (hours)
40k
50k
60k


ReliaSoft Weibull++/ALTA PRO - www.ReliaSoft.com
Reliability vs. Time
Betrouwbaarheid als functie van tijd
Reliability, R(t)=1-F(t)
Time (Hr)
Reliability
Data 1
Arrhenius
Lognormal
358
F=66 | S=0
Data Points
Reliability Line
Target Reliability
Boudewijn Jacobs
Royal Philips
11/24/2015
8:35:30 AM
Log-Std=0.141356; B=1561.301946; C=711.532889


ReliaSoft Weibull++/ALTA PRO - www.ReliaSoft.com
Unreliability vs. Time
Onbetrouwbaarheid als functie van tijd
Unreliability, F(t)=1-R(t)
Time (Hr)
Unreliability
Data 1
Arrhenius
Lognormal
358
F=66 | S=0
Data Points
Unreliability Line
Target Reliability
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Royal Philips
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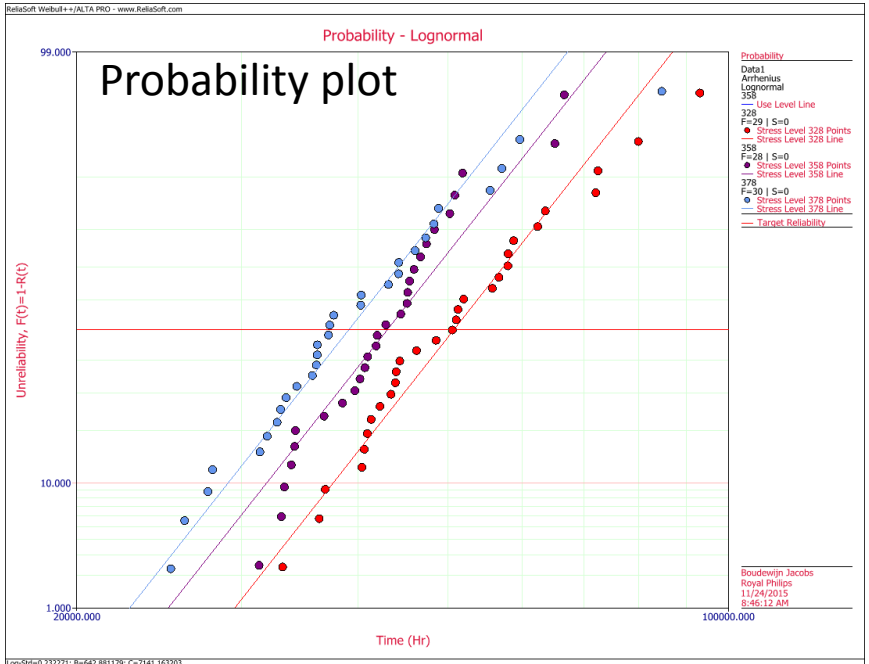
ReliaSoft Weibull++/ALTA PRO - www.ReliaSoft.com
Probability - Lognormal
Probability plot
Unreliability, F(t)=1-R(t)
Time (Hr)
Probability
Data1
Arrhenius
Lognormal
358
Use Level Line
328
F=29 | S=0
Stress Level 328 Points
Stress Level 328 Line
358
F=28 | S=0
Stress Level 358 Points
Stress Level 358 Line
378
F=30 | S=0
Stress Level 378 Points
Stress Level 378 Line
Target Reliability
Boudewijn Jacobs
Royal Philips
11/24/2015
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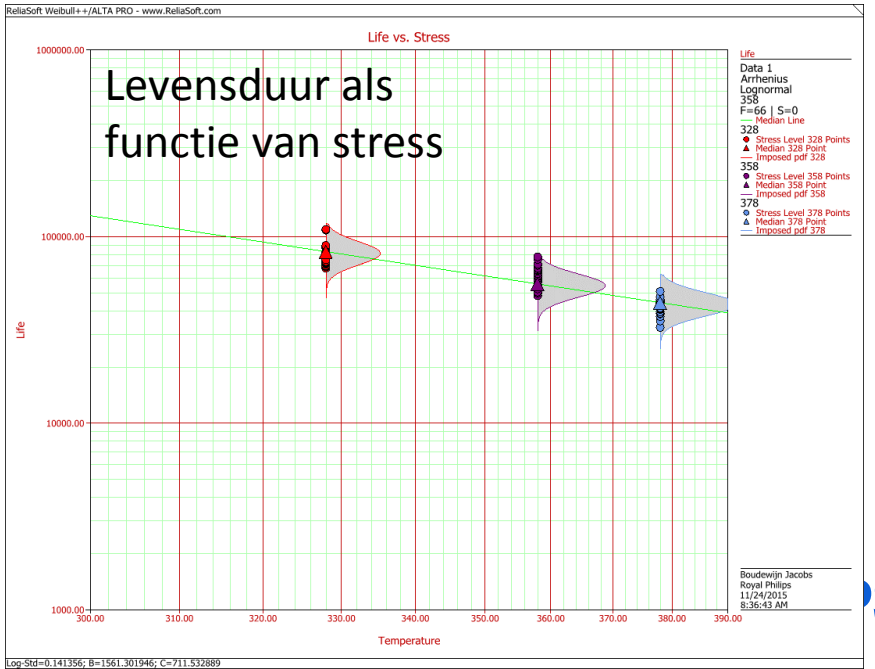
ReliaSoft Weibull++/ALTA PRO - www.ReliaSoft.com
Life vs. Stress
Levensduur als functie van stress
Life
Temperature
Life
Data 1
Arrhenius
Lognormal
358
F=66 | S=0
Median Line
328
Stress Level 328 Points
Median 328 Point
Imposed pdf 328
358
Stress Level 358 Points
Median 358 Point
Imposed pdf 358
378
Stress Level 378 Points
Median 378 Point
Imposed pdf 378
Boudewijn Jacobs
Royal Philips
11/24/2015
8:36:43 AM
Log-Std=0.141356; B=1561.301946; C=711.532889

TM-21 will utilize LM-80 data collected at multiple operating temperatures. Because of their potentially long life and impracticality of complete testing, estimates of the life of LEDs will likely be based on the extrapolation of limited test data. It is, therefore, important at this technology's early stage to be conservative in design decisions based on expected useful life.

LED Lifetime Characteristics

How do the lifetime projections for today's white LEDs compare to traditional light sources?

Light Source	Range of Typical Rated Life (hours)* (varies by specific lamp type)	Estimated Useful Life (L_{70})
Incandescent	750-2,000	
Halogen incandescent	3,000-4,000	
Compact fluorescent (CFL)	8,000-10,000	
Metal halide	7,500-20,000	
Linear fluorescent	20,000-30,000	
High-Power White LED		35,000-50,000**

*Source: lamp manufacturer data.

**Depending on drive current, operating temperature, etc. some manufacturers are claiming useful life (L_{70}) values greater than 100,000 hours.

Electrical and thermal design of the LED system or fixture determine how long LEDs will last and how much light they will provide. Driving the LED at higher than rated current will increase relative light output but decrease useful life. Operating the LED at higher than design temperature will also decrease useful life significantly.

Most manufacturers of high-power white LEDs estimate a lifetime of around 30,000 hours

www.eere.energy.gov

For Program Information on the Web:
www.ssl.energy.gov
DOE sponsors a comprehensive program of SSL research, development, and commercialization.

For Program Information:
Robert Lingard
Pacific Northwest National Laboratory
Phone: (503) 417-7542

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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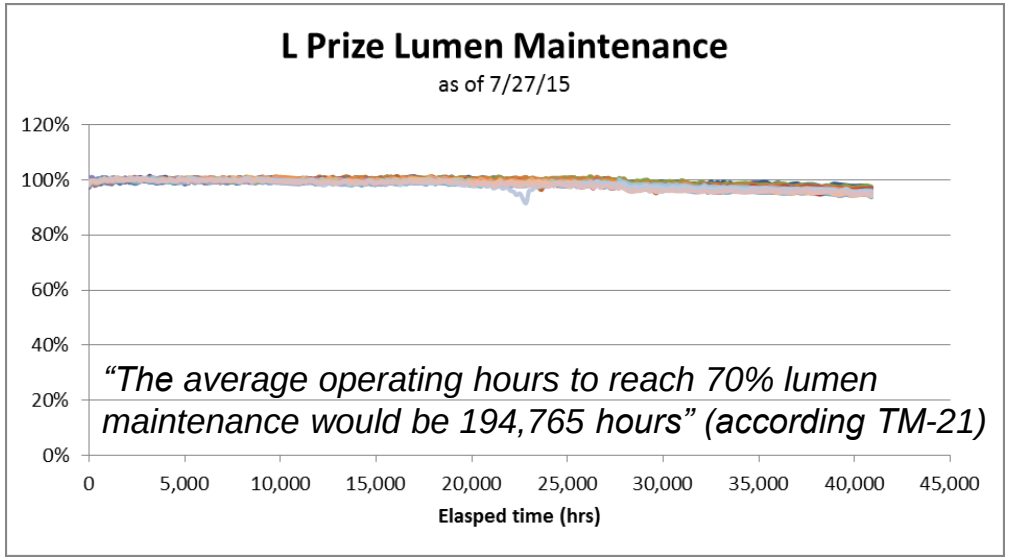
L•PRIZE®

Lumen Maintenance Testing of the Philips 60-Watt Replacement Lamp L Prize Entry

Updated July 2013



Stress testing result: "Philips L Prize Entry Analysis : Due to the lack of any design-intent failures on the Philips L Prize entry lamps, no meaningful failure analysis could be done."

Voorbeeld van toepassing van omgevingstesten (damp heat steady state) om de levensduur te voorspellen

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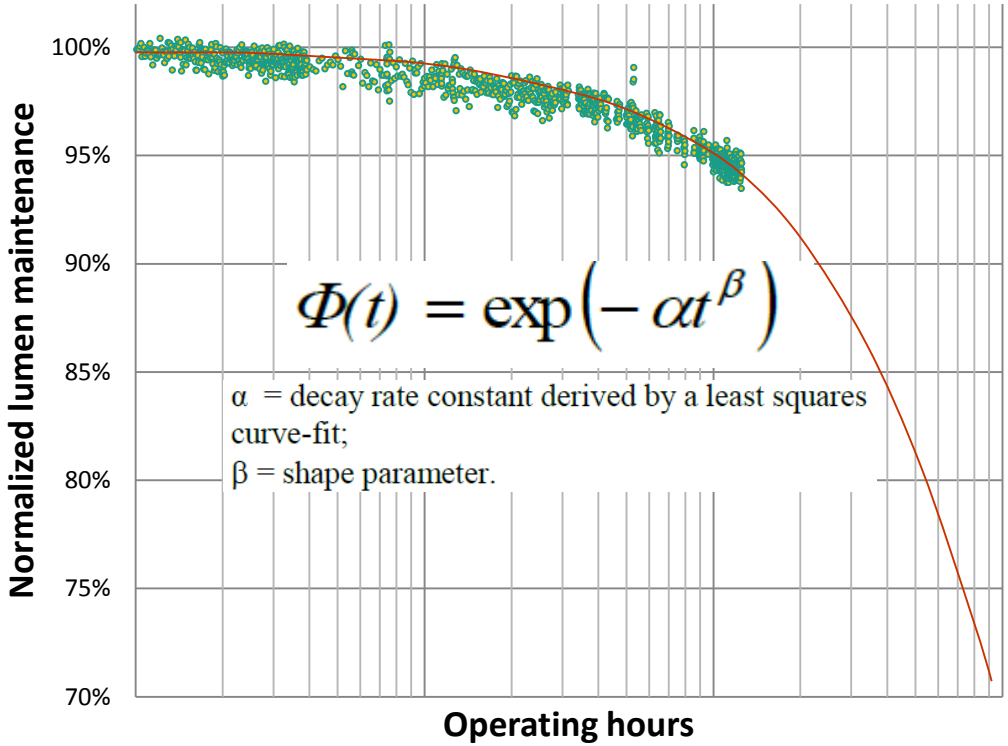
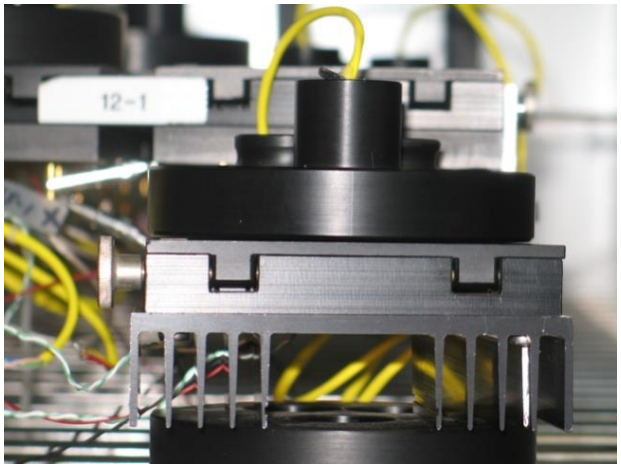
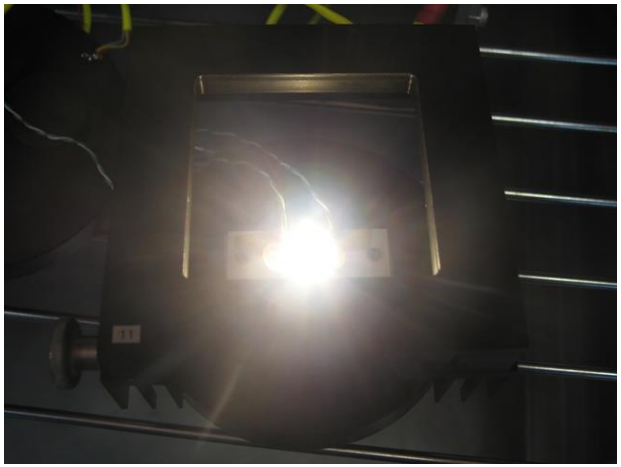


$$\alpha = A \exp\left(\frac{-E_a}{k_B T_s}\right) I^n$$

$$L_{70} = \left(-\ln(0.7)/\alpha\right)^{1/\beta}$$





Kunnen we de testtijd verkorten middels versneld testen ?

De acceleratie factor voor de afname van de lichtintensiteit wordt gegeven door:

$$AF = \left[\frac{E_{stress\ application}}{E_{stress\ accelerated}}\right]^{-p} \cdot \left[\frac{L_{application}}{L_{accelerated}}\right]^{-r} \cdot \left[\frac{RH_{application}}{RH_{accelerated}}\right]^{-n} \cdot e^{\frac{E_a}{k}\cdot\left(\frac{1}{T_{application}} - \frac{1}{T_{accelerated}}\right)}$$

Where

E_{stress} = Electrical stress
p = electrical dependent parameter
L = Load
r = added stress depended parameter
RH = Relative Humidity (%)
n = Humidity depended parameter
Ea= Activation energy (eV)
k = Boltzmann's constant
T = Temperature (K)

Test ID	Test	Condition	Testing time	
1	WHTOL	T_{amb} 60˚C / 90 % R.H. 120 mA	6000 hrs	Model building
2	WHTOL	T_{amb} 85˚C / 85 % R.H. 120 mA	6000 hrs	
3	WHTOL	T_{amb} 85˚C / 45 % R.H. 120 mA	6000 hrs	
4	LM-80	T_s 55˚C	4000 hrs	
5	LM-80	T_s 85˚C	4000 hrs	
6	LM-80	T_s 105˚C	4000 hrs	
A	HTOL	T_s 92˚C and T_s 107˚C	10000 hrs	Model verification
B	HTOL	T_s 95˚C and T_s 105˚C	10000 hrs	

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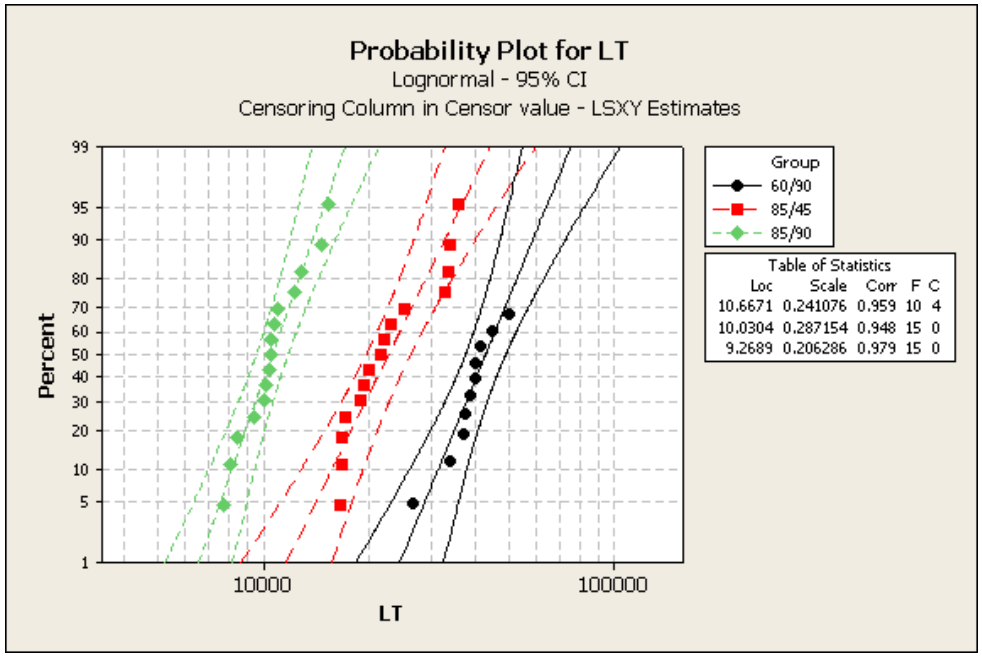
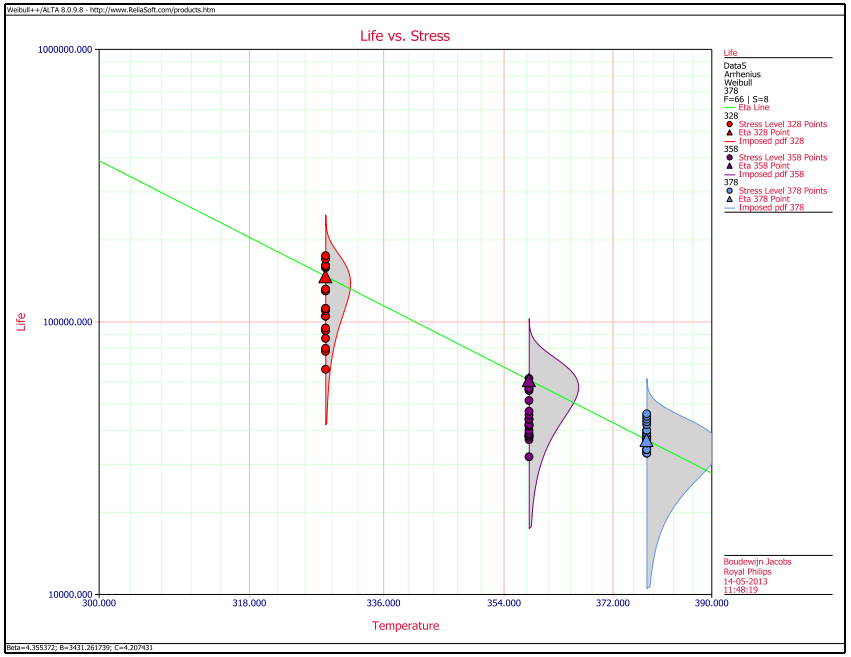
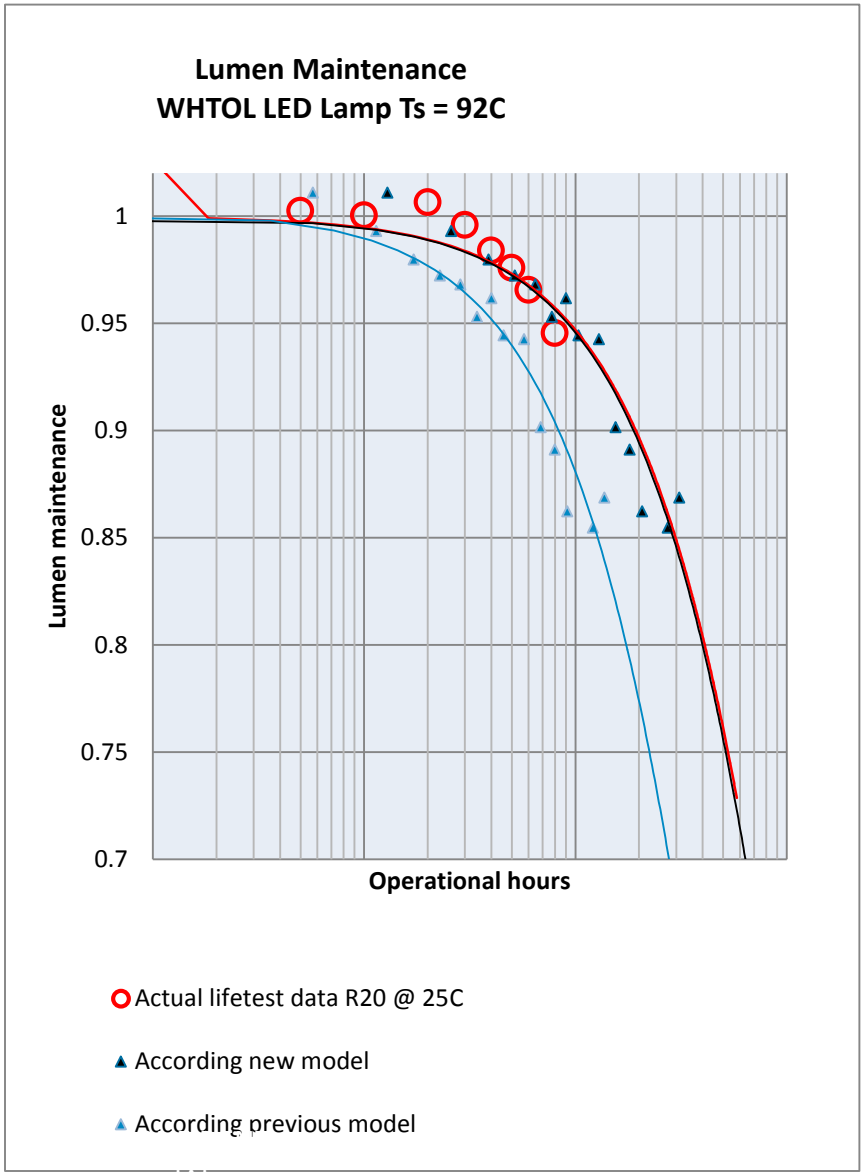
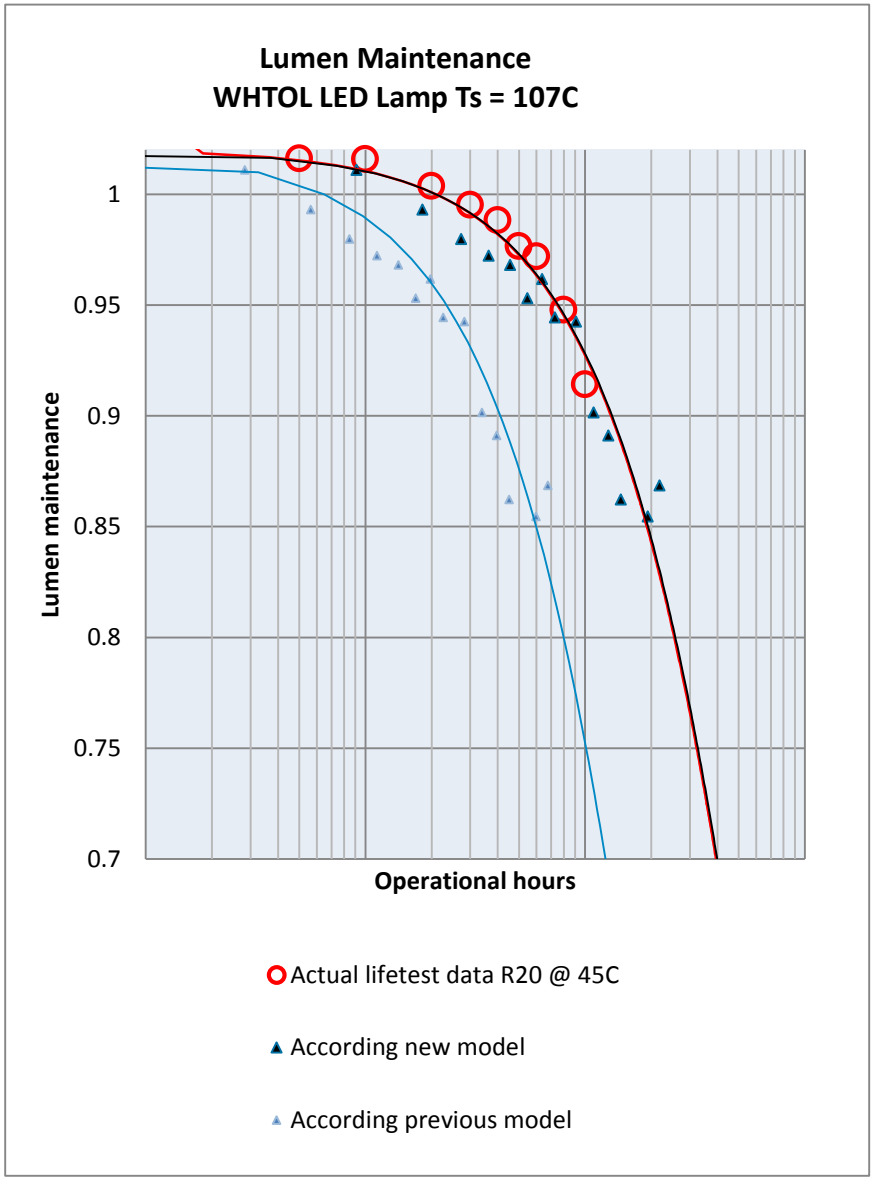




$$AF = \left[\frac{E_{stress\ application}}{E_{stress\ accelerated}}\right]^{-p} \cdot \left[\frac{L_{application}}{L_{accelerated}}\right]^{-r} \cdot \left[\frac{RH_{application}}{RH_{accelerated}}\right]^{-n} \cdot e^{\frac{E_a}{k}\cdot\left(\frac{1}{T_{application}} - \frac{1}{T_{accelerated}}\right)}$$


Lumen Maintenance
WHTOL LED Lamp Ts = 92C
Lumen maintenance
1
0.95
0.9
0.85
0.8
0.75
0.7
Operational hours
Actual lifetest data R20 @ 25C
According new model
According previous model


Lumen Maintenance
WHTOL LED Lamp Ts = 107C
Lumen maintenance
1
0.95
0.9
0.85
0.8
0.75
0.7
Operational hours
Actual lifetest data R20 @ 45C
According new model
According previous model

Voorbeelden van faalmechanismen

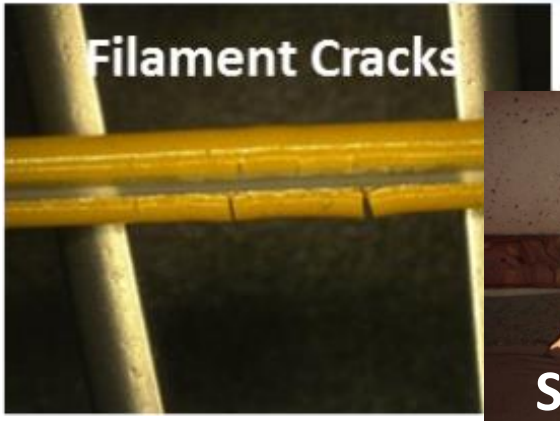

Cracks in lenses


Browning

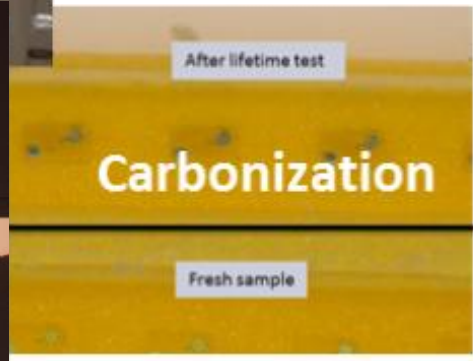

Burned LEDs

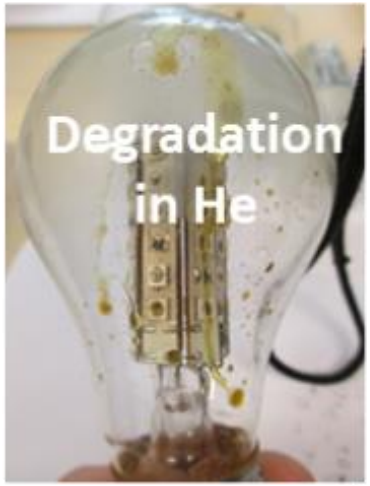

Color shift

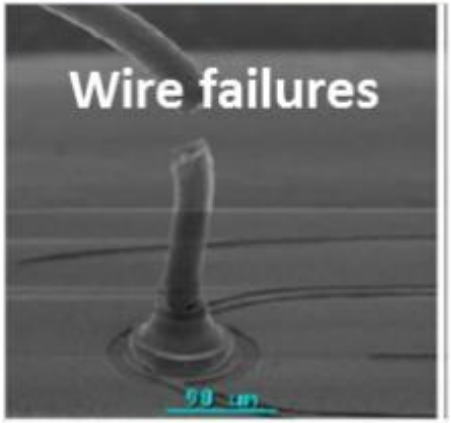

Exploded LEDs


Filament Cracks

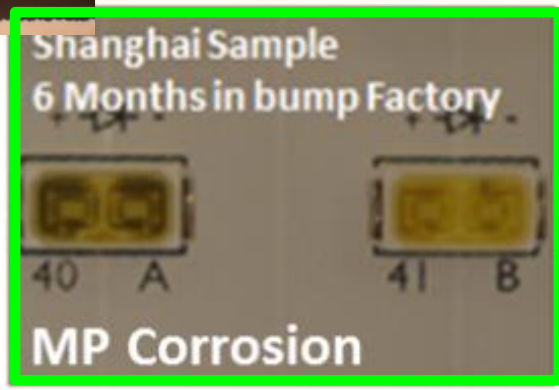

Solderjoint
fatigue


After lifetime test
Carbonization
Fresh sample

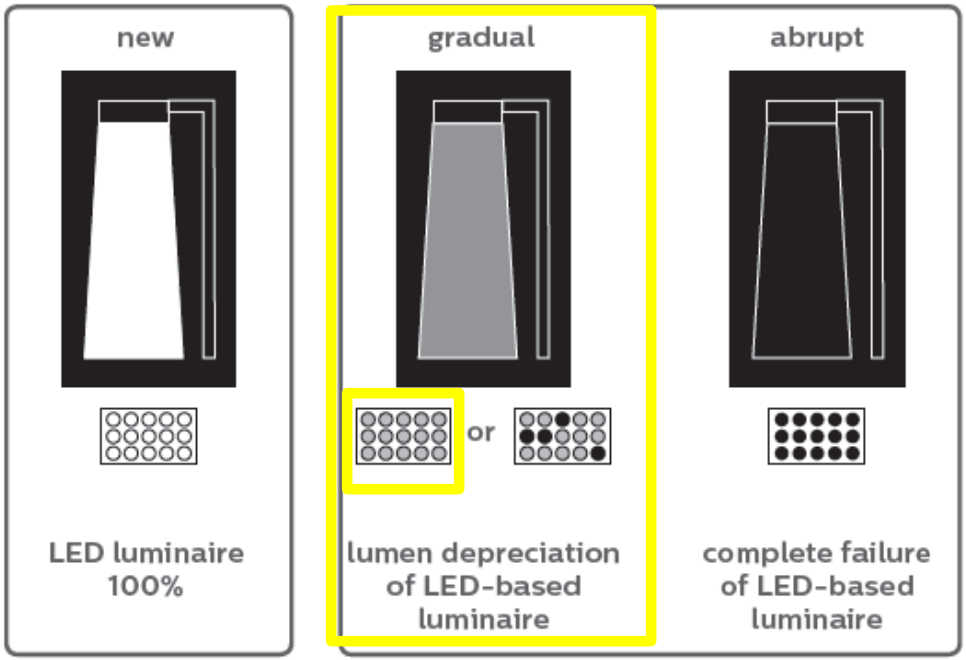

Degradation
in He

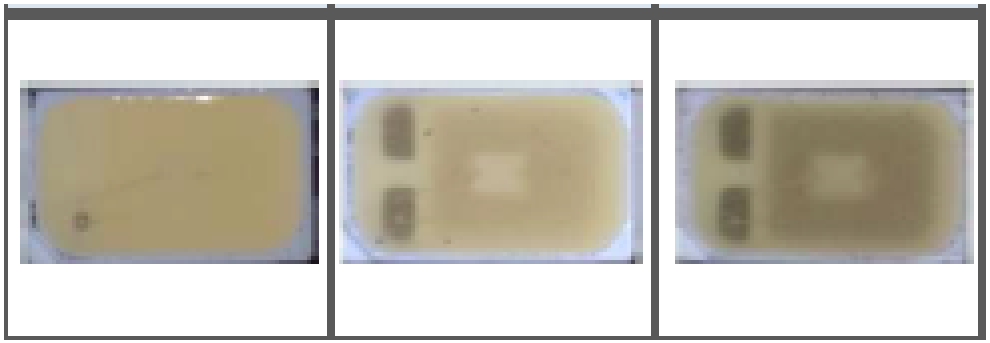

Wire failures


Hipot
D5
C
C5


Shanghai Sample
6 Months in bump Factory
40
A
41
B
MP Corrosion

Corrosie van zilverspiegel in LP/MP LEDs is één van de belangrijkste oorzaken bij een geleiderlijkse vermindering van de lichtintensiteit





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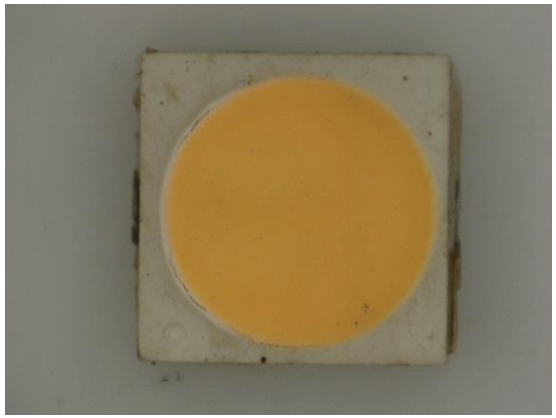
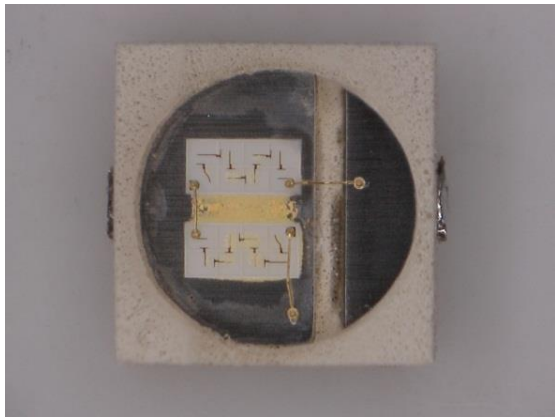
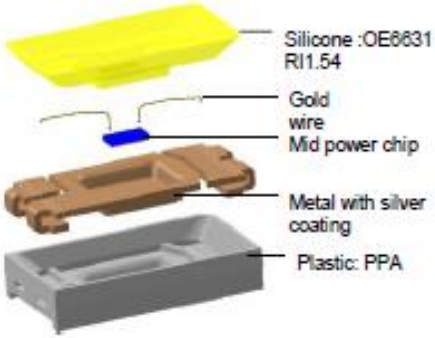
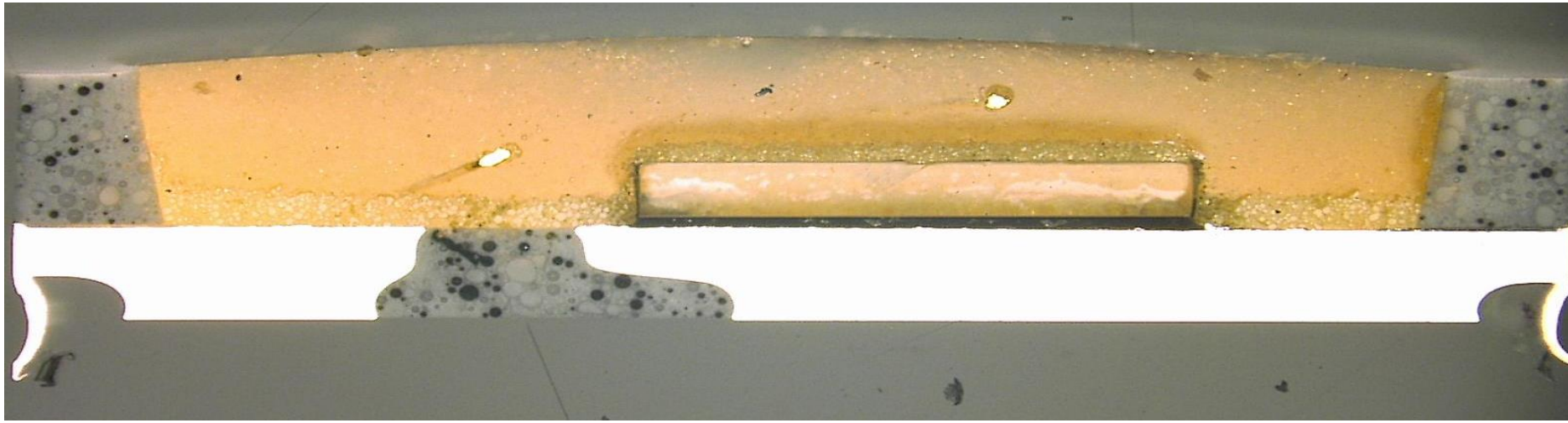
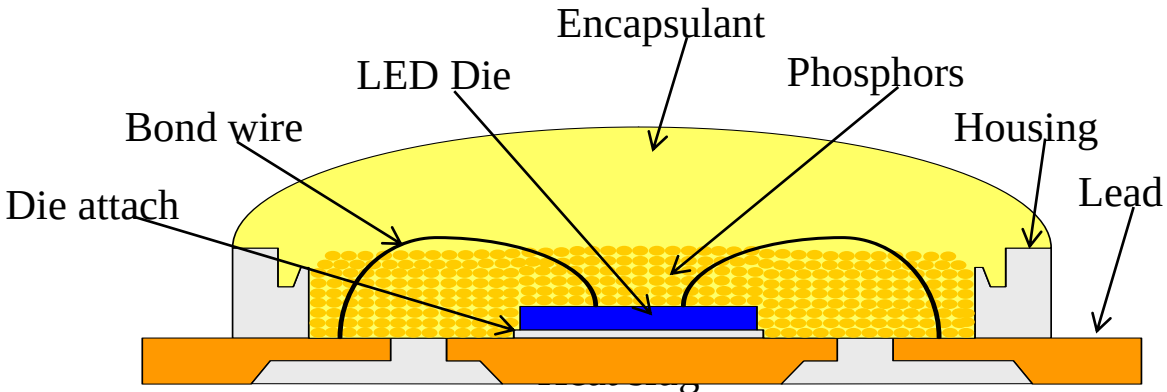
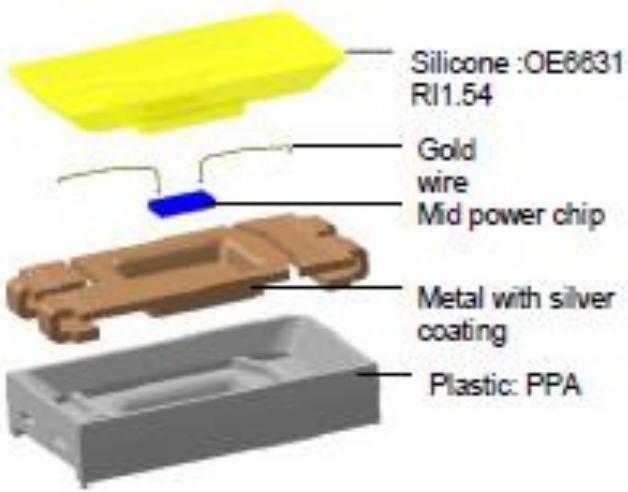


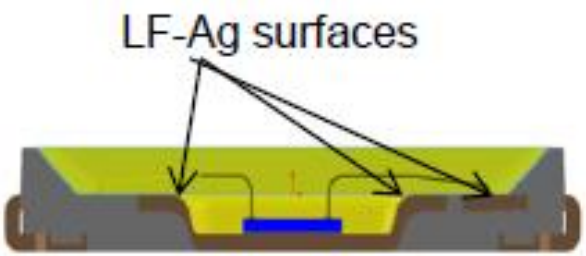


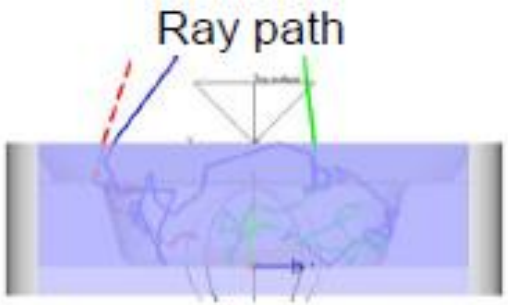




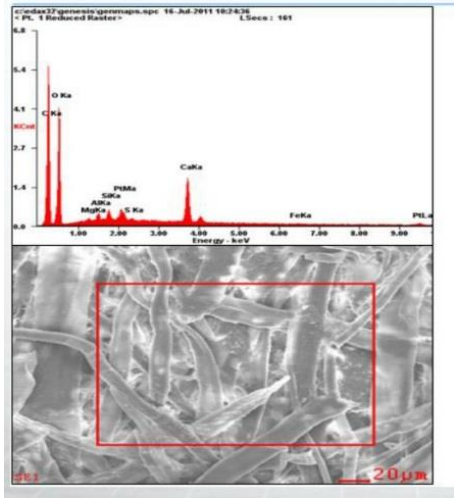








Pic from Rayset file
Most rays in the bottom cup



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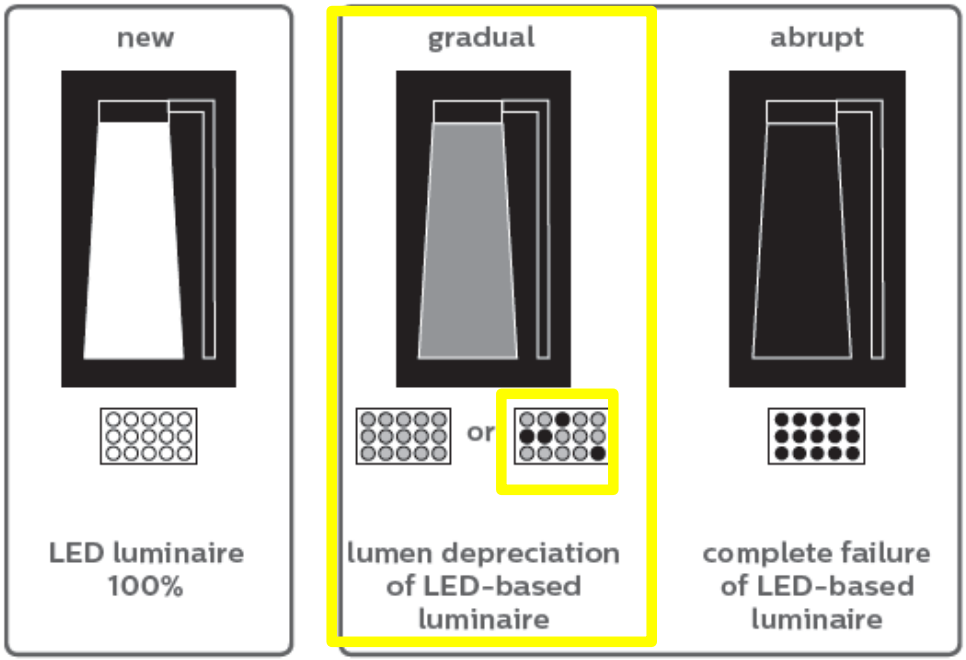
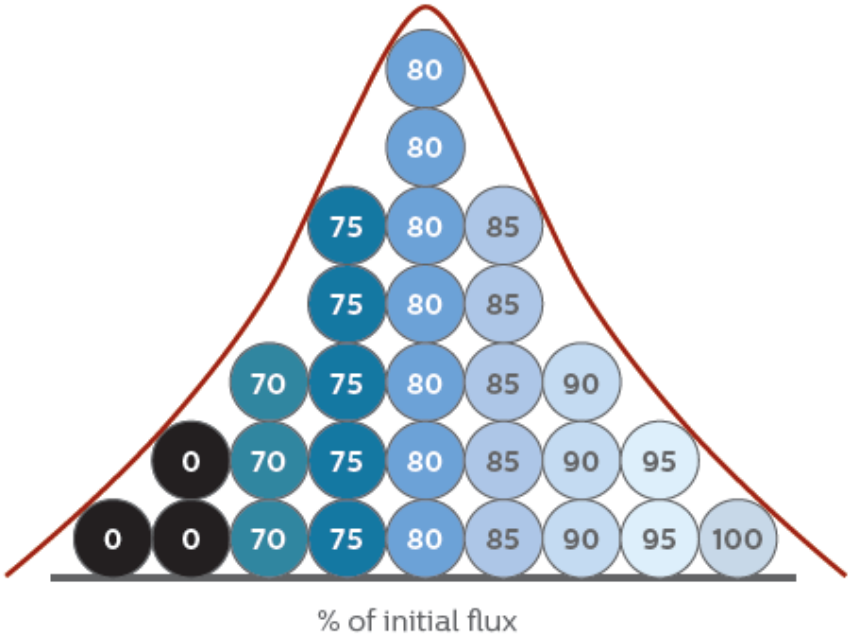
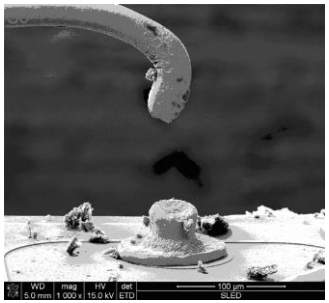
Wirebond failure is één van de belangrijkste oorzaken bij een abrupte afname van de lichtintensiteit op LED niveau







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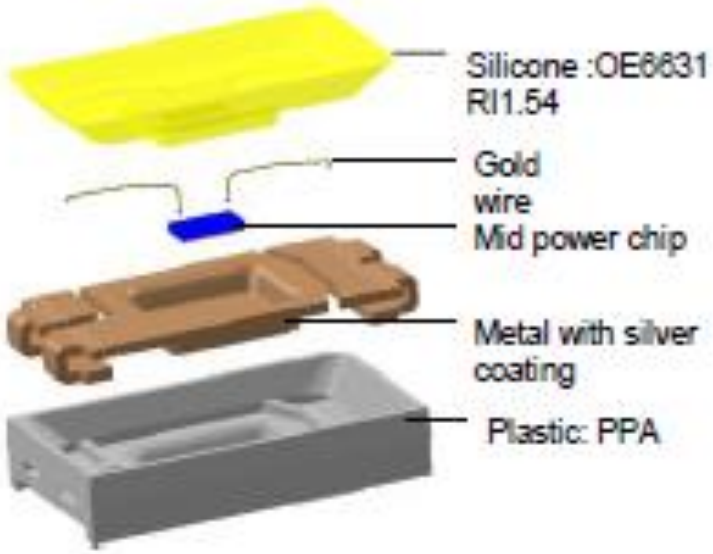
Silicone :OE6631
RI1.54
Gold
wire
Mid power chip
Metal with silver
coating
Plastic: PPA