Lamp measurement report - 18 Aug 2020

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Summary measurement data dated 2020-08-18

parameter	meas. result	remark
Color temperature	2737 K	warm white
Luminous intensity I_v	2597.6 Cd	Measured straight underneath the lamp.
Illuminance modulation index	2 %	Measured with a light sensor looking at the lamp (angle not defined). Is a measure for the amount of flickering.
SVM	0.0	Stroboscopic Visibility Measure, and must be = 0.4 at full-load per EU regulation 2019/2020.
Beam angle	24 deg	24 deg is the beam angle for all C-planes since the lamp is symmetrical along its 1st axis. Flux code: 99 99 100 100 100.
Power P	8.6 W	The net power consumed.
Power Factor	0.98	An electrical load with this power factor means that for every 1 kWh net energy consumed, there has been 0.21 kVAhr for reactive energy.
THD	11 %	Total Harmonic Distortion.
Max inrush current	0.190 A	This current has been found at a voltage start angle of 80 degrees.
Luminous flux	664 lm	Measured with photogoniometer, calculation done as described in LM79-08.
Luminous efficacy	77 lm/W	
EU2013-label classification	A+	The energy class, from A++ (more efficient) to E (least efficient). This label is an update of the previous version, and compulsory from Sept 2013.
CRI_Ra	96	Color Rendering Index.
Rf_TM30	95	TM30-15 is an improved indicator (over CRI) of how well colors are rendered.
Rg_TM30	103	Gamut Area Ratio.
Coordinates chromaticity diagram	x=0.4552 en y=0.4068	
Fitting	230V	This lamp is connected directly to the grid voltage.
S/P ratio	1.4	This factor indicates the amount of times more efficient the light of this light bulb is perceived under scotopic circumstances (low environmental light level).
D x H external dimensions	119 mm x 155 mm	External dimensions of the lamp.

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parameter	meas. result	remark
D luminous area	100 mm	Dimensions of the luminous area (used in Eulumdat file). It is the surface of the reflector.
General remarks		The ambient temperature during the whole set of illuminance measurements was 24.1 - 24.6 deg C. The temperature of the lamp gets maximally about 21.5 degrees hotter than ambient temperature. Warm up effect: During the warmup time the illuminance doesn't vary significantly (5 %). During the warmup time the power doesn't vary significantly (5 %). The variation in efficacy (calculated as indication by simply dividing the illuminance by the power) during the warming up is -0 %. A very high negative value indicates a significant decrease for instance due to heating up of the lamp (decrease of lifetime). Voltage dependency: There is no (significant) dependency of the illuminance when the power voltage varies between 200 - 250 V . There is no (significant) dependency of the consumed power when the power voltage varies between 200 - 250 V . Also the dim-ability of this lamp has been tested, and the result is that the lamp is dim-able, see also the separate chapter in this test report. At the end of the article an additional photo.
Eff-variation	-0 %	This is the variation in efficacy (calculated as indication by simply dividing the illuminance by the power) during the warming up. A very high negative value indicates a significant decrease for instance due to heating up of the lamp (decrease of lifetime).
Dimmable	yes	Info from manufacturer.
Melanopic effect factor	0.436	According to norm DIN SPEC 5031-100:2015-08.
Melanopic Ratio	0.36	This ratio multiplied with the lux value gives the EML-value (Equivalent Melanopic Value), used in table L2 of WELL std 2019-Q3.
Blue Light Hazard risk group	0	0=exempt, 1=low, 2 = moderate, 3=high risk. Indication value only for straight underneath the lamp.
form factor	spot	
article number	001	

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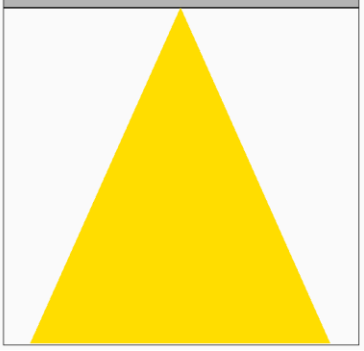
parameter	meas. result	remark
Brand	TovLED	

Overview table

m.	Ø 50% C0-180	Ø 50% C90-270	E (lux)
0.5	0.2	0.2	10390
0.75	0.3	0.3	4618
1	0.4	0.4	2598
1.25	0.5	0.5	1662
1.5	0.6	0.6	1154
1.75	0.8	0.8	848
2	0.9	0.9	649

C0-180: 24°
C90-270: 24°



Luminaire Efficacy	
77	(lumen per Watt)
Half-peak diam C_{0-180}	
0.22	x diameter(m)
Half-peak diam C_{90-270}	
0.22	x diameter(m)
Illuminance	
2598	/ distance^2(lux)
Total Output	
664	(lumen)

Please note that this overview table makes use of calculations, use this data with care as explained on the OliNo site.

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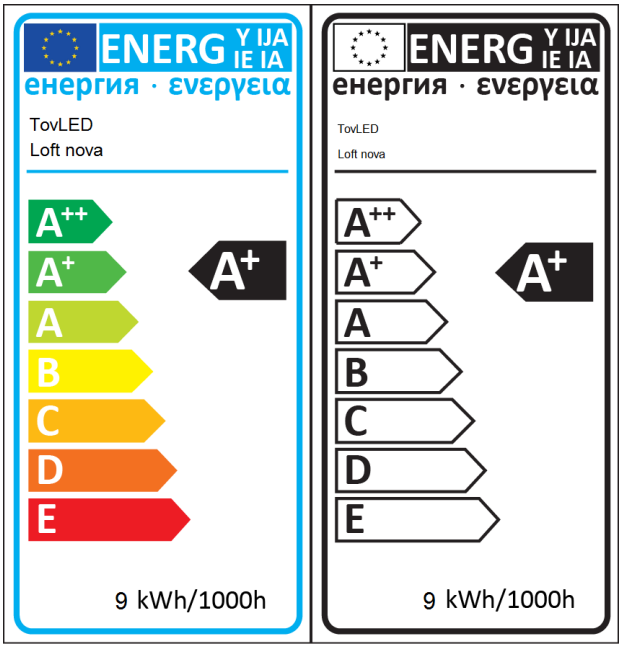
EU 2013 Energy label classification

Since Sept 2013 these labels will be needed.

Important for the energy classification are the corrected rated power and the useful luminous flux.
The measured rated power is 8.6 W and might need to be corrected. The correction is dependent from the lamp type and whether or not the lamp control gear is included or not. The choice for this lamp is the following classification: **Lamps with own control gear (external or internal)**. As a result the corrected rated power becomes: 8.6 W.
The luminous flux measured is 664 lm. The classification of this lamp needed to determine the useful flux is: **Other directional lamps**. Then the useful flux becomes 655 lm. Now a reference power can be calculated.

The energy efficiency coefficient is P_corr / P_ref = 0.16.



EU energy label for this lamp

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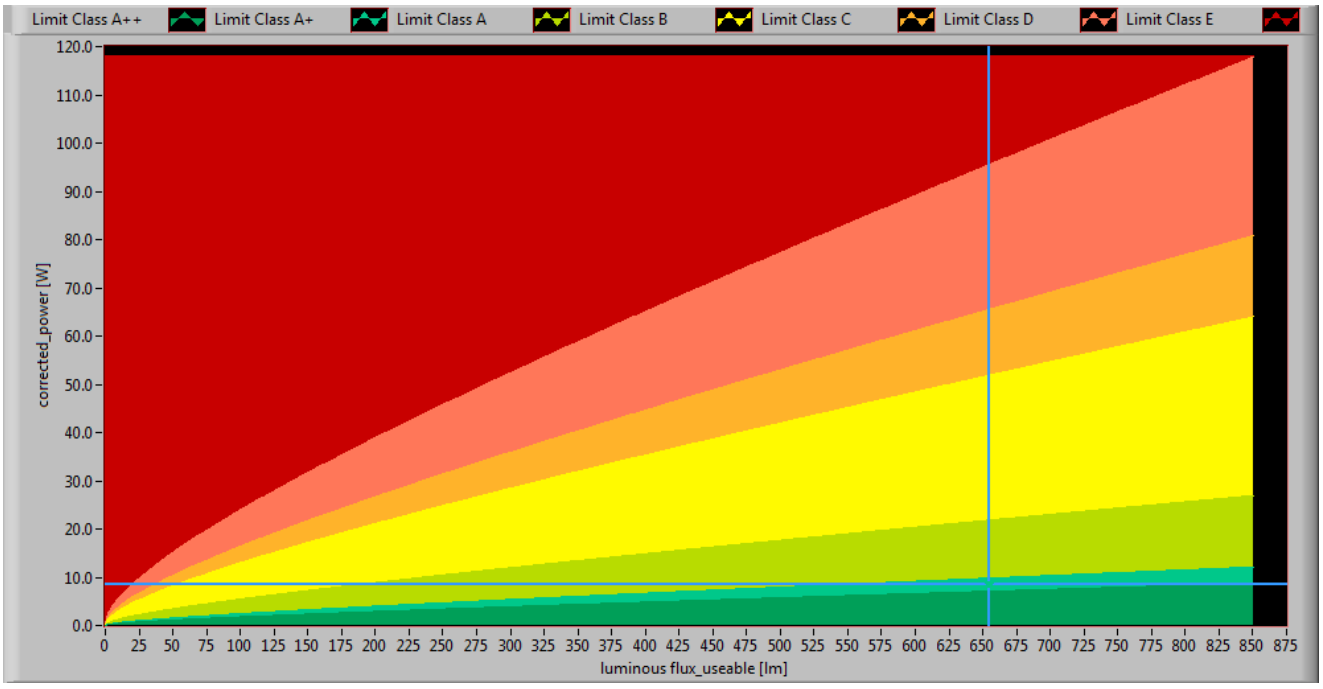

The lamp's performance in the lumen-Watt field, with the energy efficacy fields indicated.

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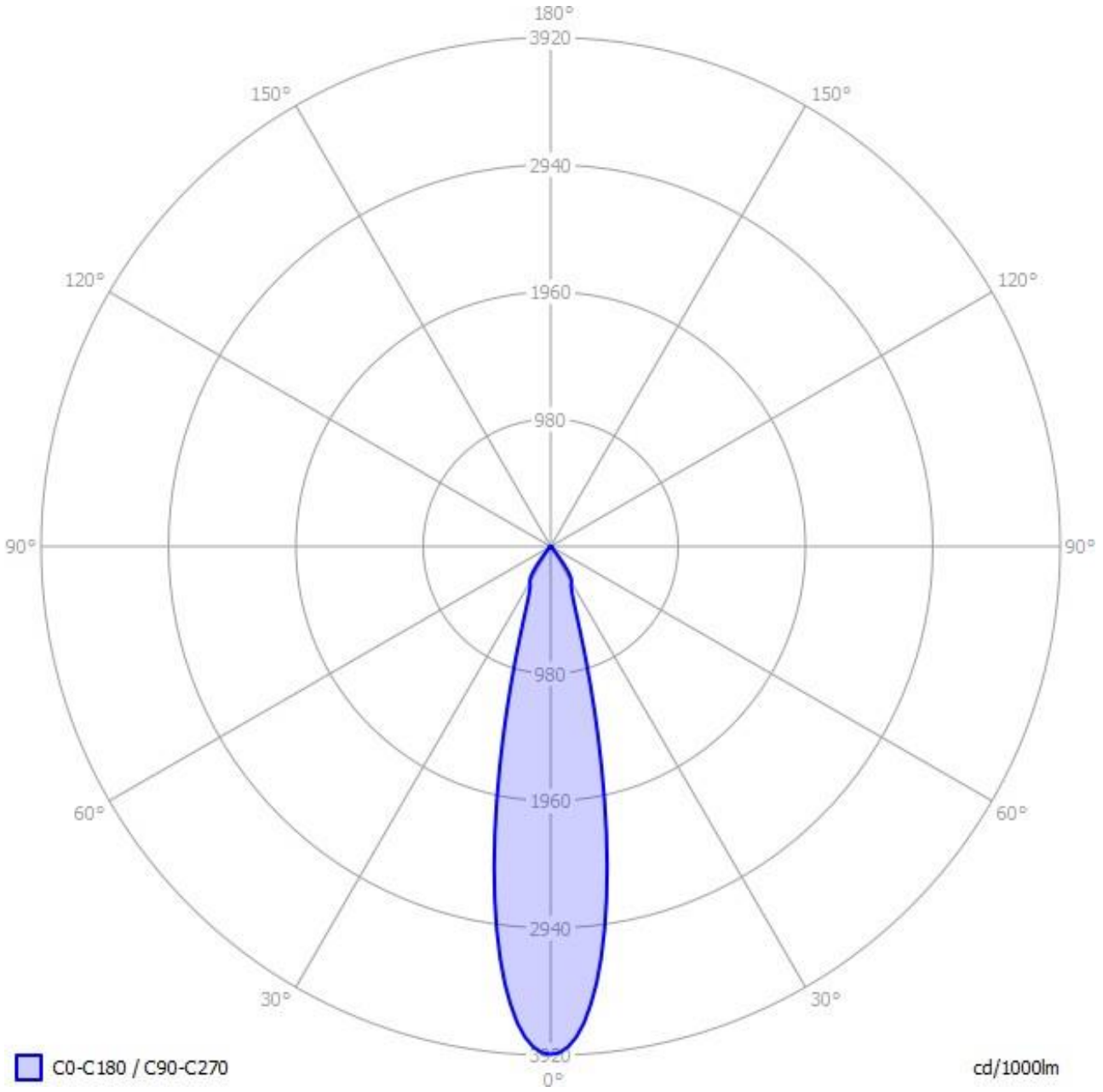
Eulumdat light diagram

This light diagram below comes from the program Qlumedit, that extracts these diagrams from an Eulumdat file.



The light diagram giving the radiation pattern.

The light diagram indicates the beam in the C0-C180 plane and in the plane perpendicular to that, the C90-C270 plane. These beams are equal as the lamp has symmetry over its first axis (the vertical axis).

When using the Ev or Iv values per inclination angle, the beam angle can be computed, being 24 deg for the C0-C180 plane and 24 deg for the C90-C270 plane.

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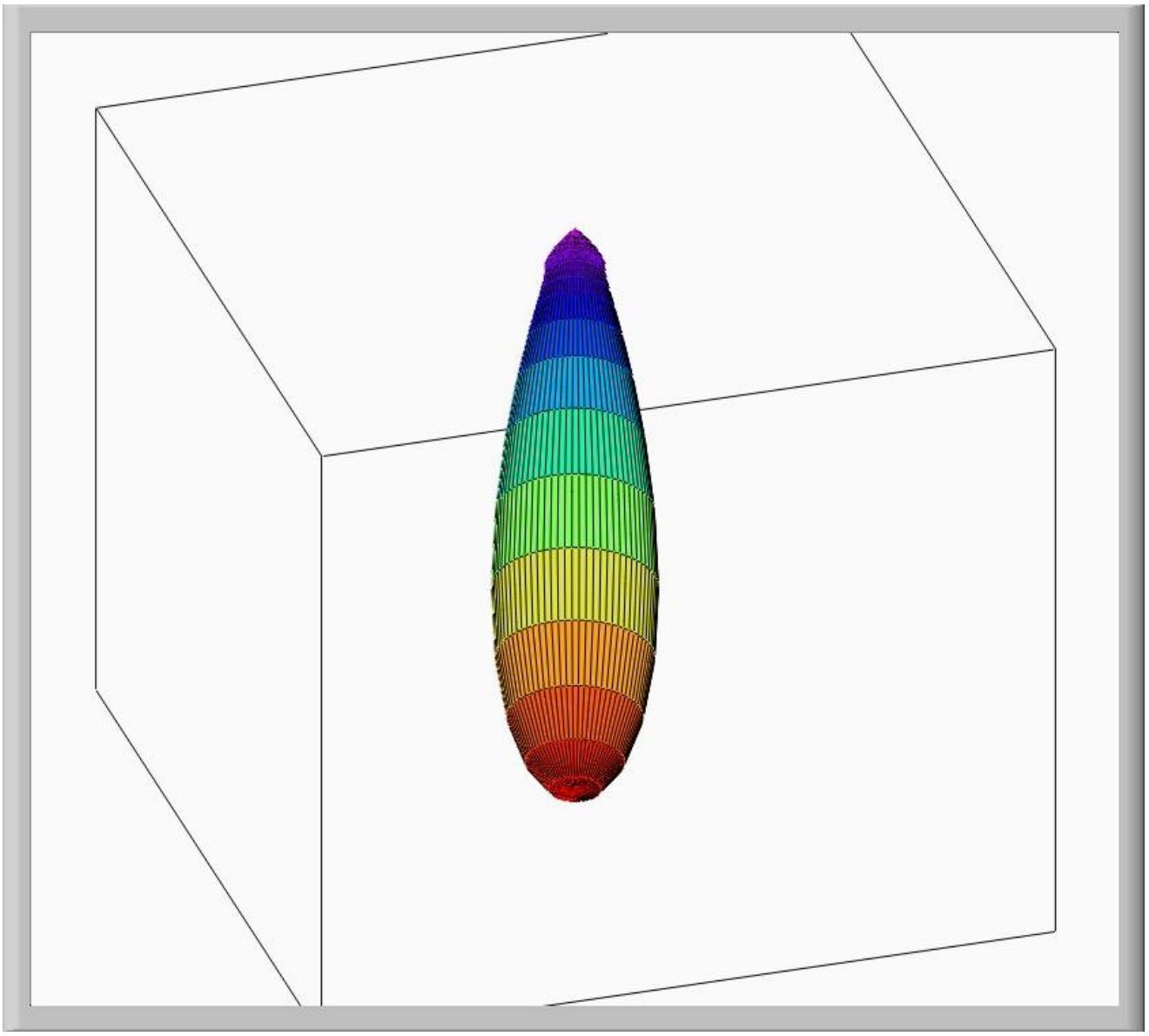

Image of the light distribution pattern in 3D.

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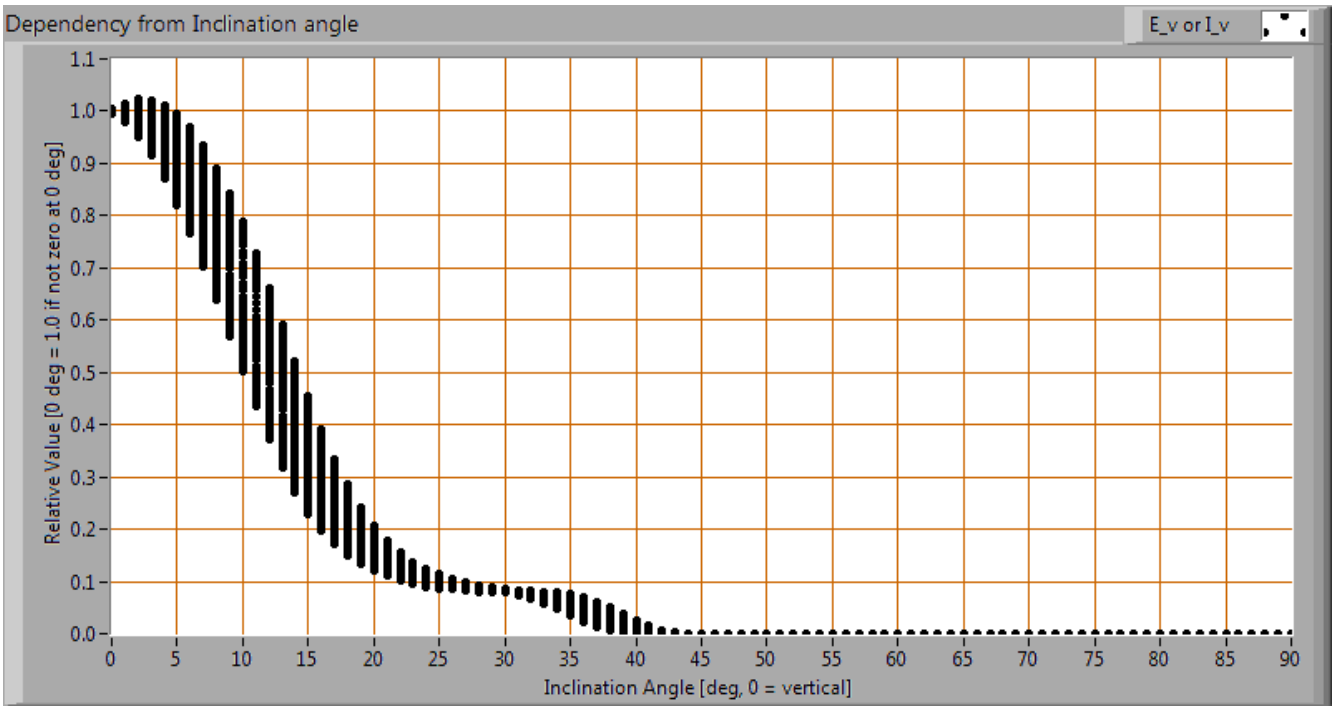

Intensity data of every measured turn angle at each inclination angle.

This plot shows per inclination angle the intensity measurement results for each turn angle at that inclination angle. There normally are differences in illuminance values for different turn angles. However for further calculations the averaged values will be used.

Luminous flux

With the averaged illuminance data at 1 m distance, taken from the graph showing the averaged radiation pattern, it is possible to compute the luminous flux.

The result of this computation for this light spot is a luminous flux of 664 lm.

Luminous efficacy

The luminous flux being 664 lm, and the consumed power of the lamp being 8.6 Watt, results in a luminous efficacy of 77 lm/Watt.

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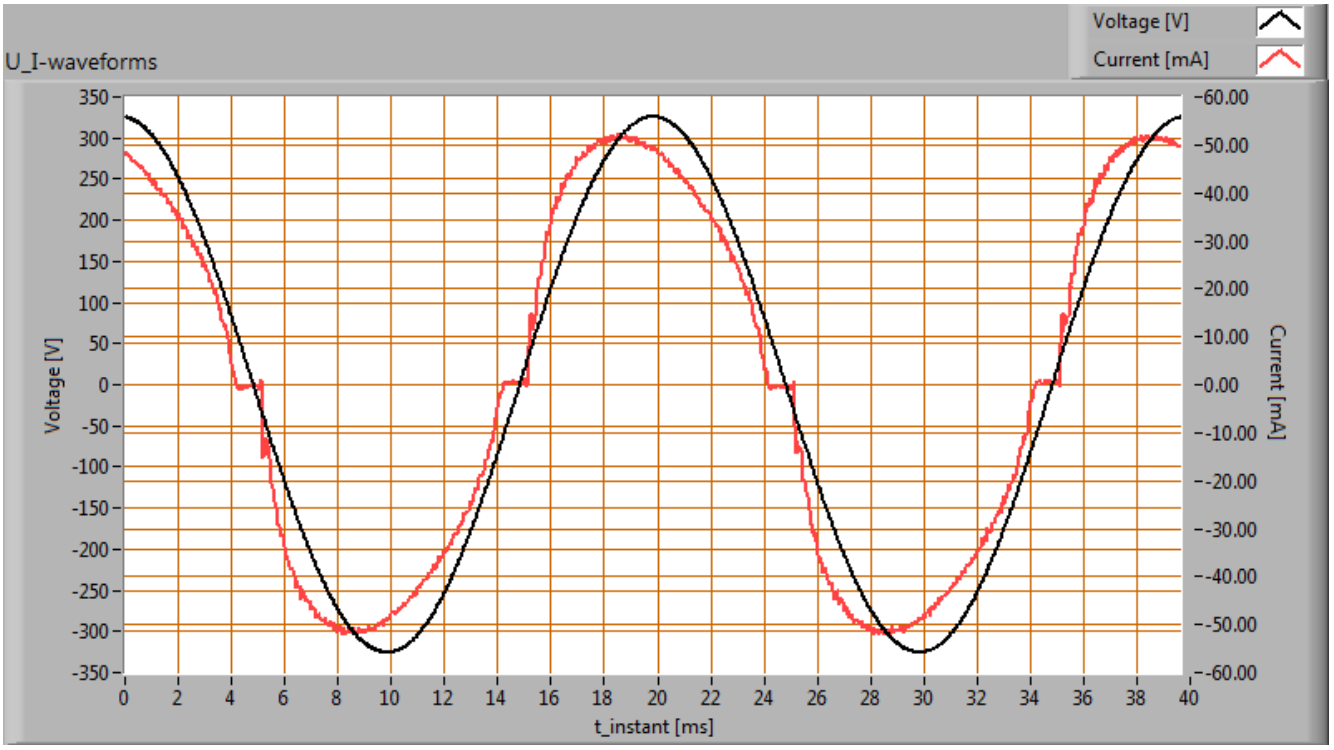
Electrical properties

The power factor is 0.98. An electrical load with this power factor means that for every 1 kWh net energy consumed, there has been 0.21 kVAhr for reactive energy.

Lamp voltage	230.25 V
Lamp current	0.038 A
Power P	8.6 W
Apparent power S	8.8 VA
Power factor	0.98

Of this lamp the voltage across and the resulting current through it are measured and graphed.



Voltage across and current through the lightbulb

This current waveform has been checked on requirements posed by the norm IEC 61000-3-2:2018. This norm contains requirements for lamps with a power 5 W, 5 - 25 W and > 25 W. This lamp consumes 8.6 W.
NOTE: standard only applies to lamps with supply voltages higher than 220 V AC.

When power is from 5 to and including 25 W there are requirements for the current. At least one of the three requirements given below, must be passed.

1) Requirement for harmonics and form of the current:

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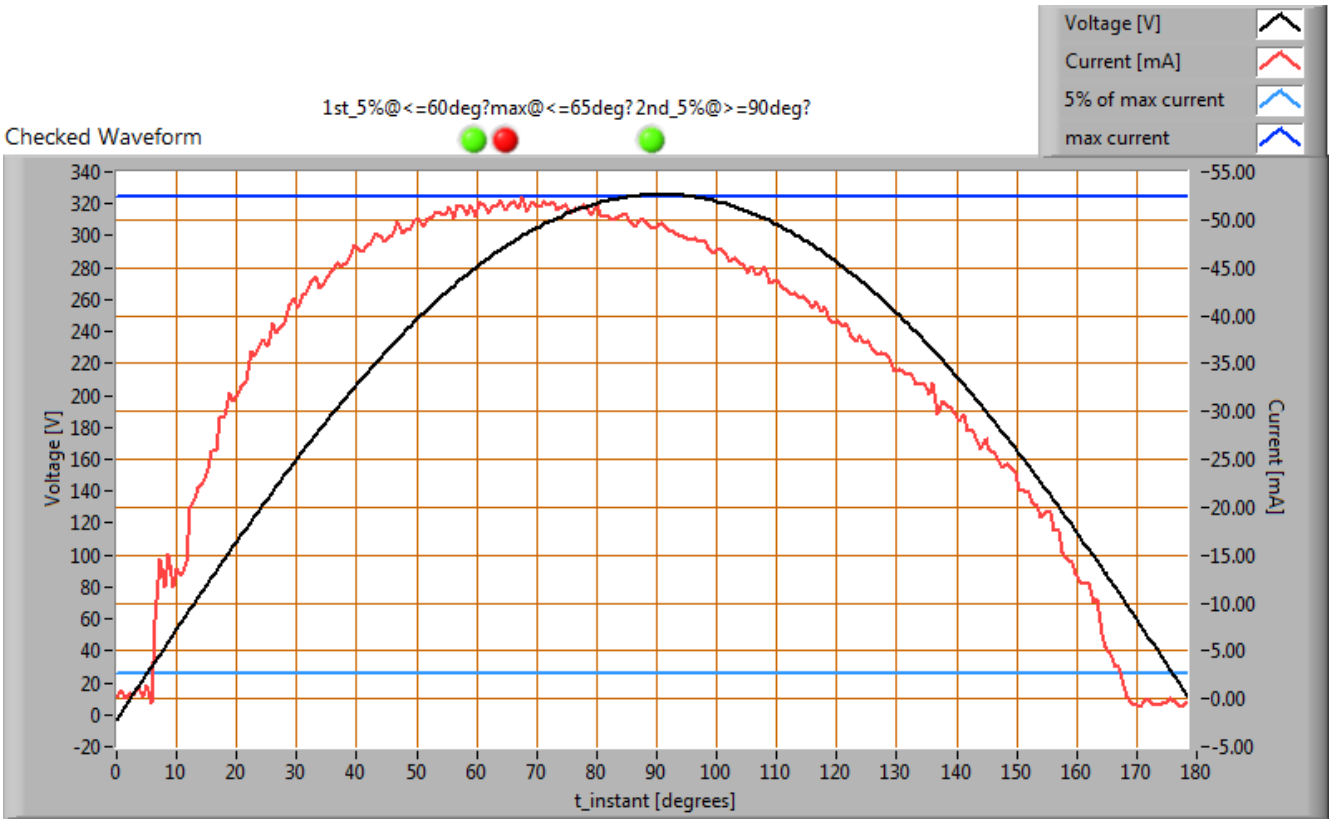
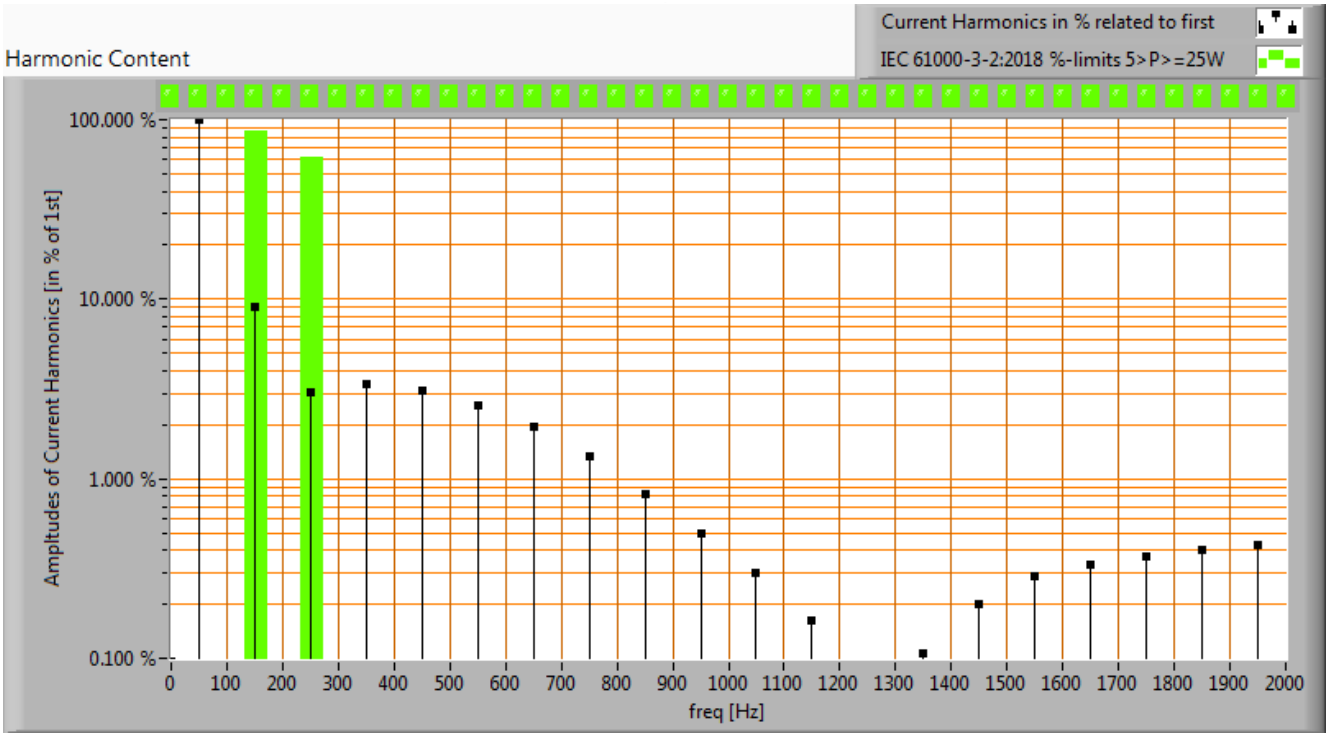


Requirements on the form of the current in IEC61000-3-2:2018



The harmonics in the current compared to requirements in IEC61000-3-2:2018, that belong to the requirement of the form of the current.

2) Harmonic currents less than power-threshold values:

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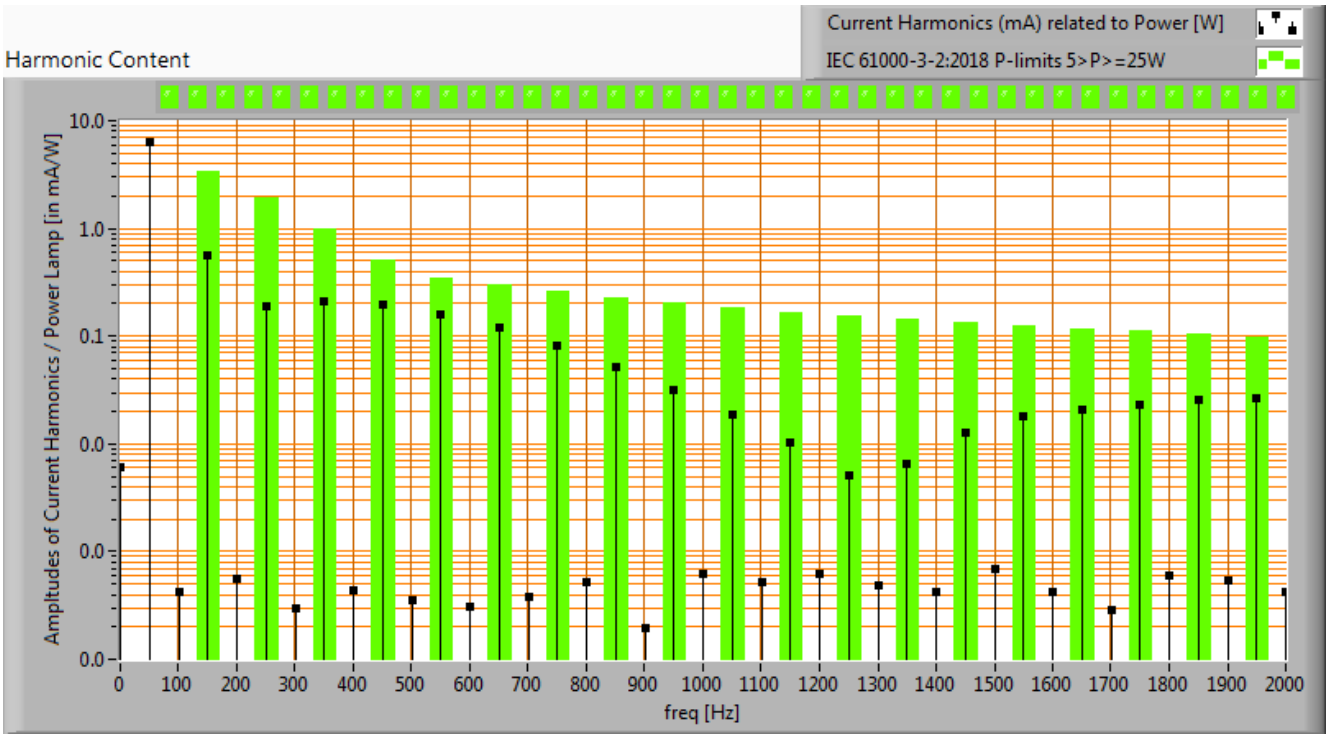
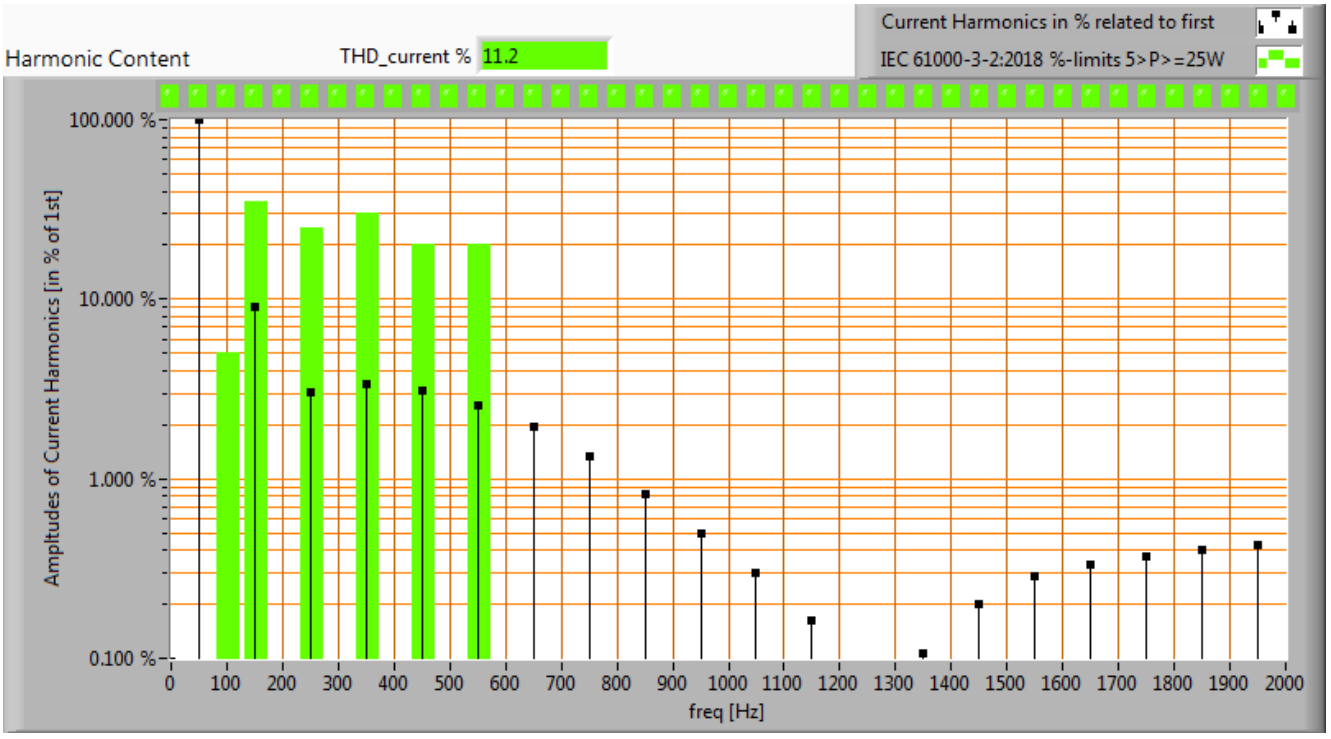


The harmonics in the current compared with maximum values in mA per Watt, as given in IEC61000-3-2:2018.

3) Maximum value for THD (= 70 %) and for harmonics:



The harmonics of the current compared to maximum levels in IEC61000-3-2:2018, these levels belong together with the requirement of the maximum THD value.

The requirements in norm IEC61000-3-2:2018 are met.

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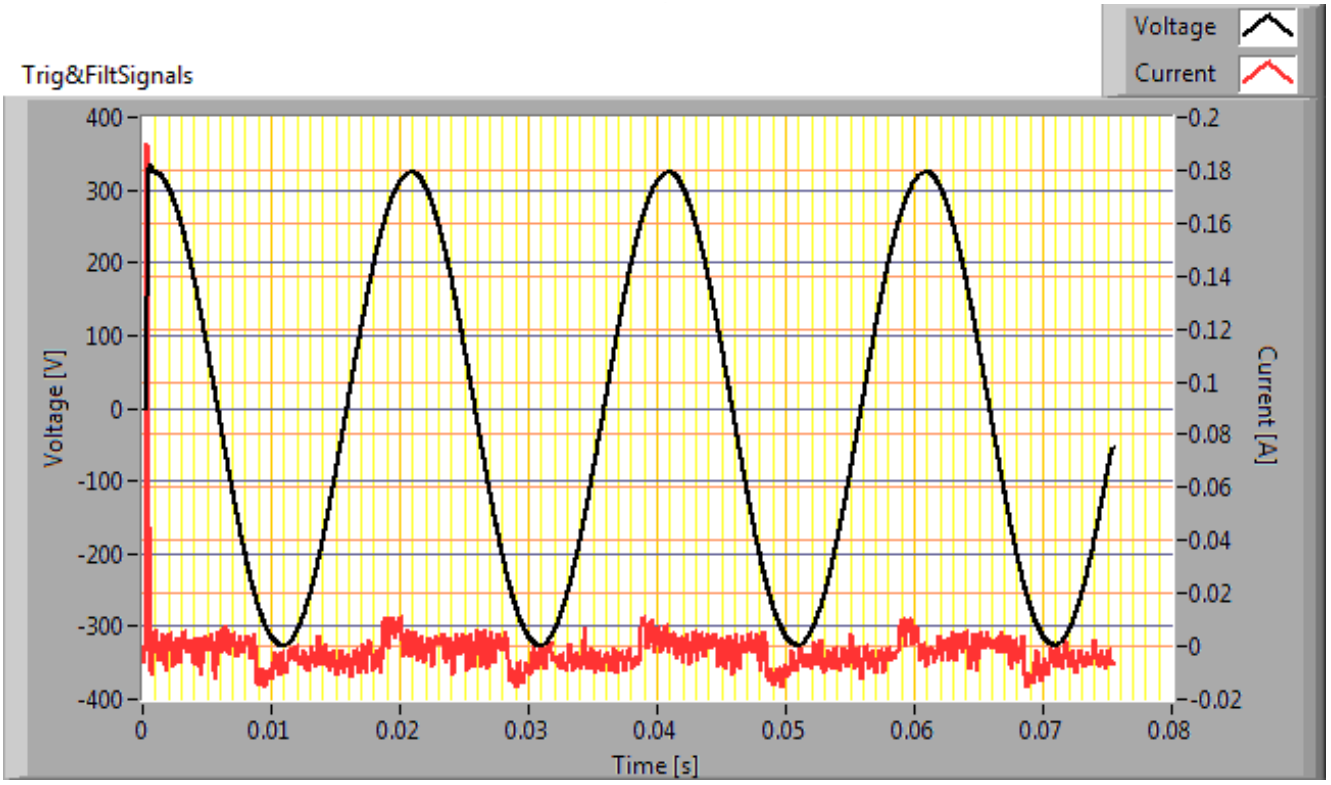
Inrush current

The inrush current has been measured for different voltage start angles; from 0 - 170 degrees with a 10 degrees step. The current- and voltage values have been acquires at a sample speed of 39.9 kS/s. Then this data has been fed into a second order 2kHz low pass Butterworth filter. This removes the current spikes that do not represent relevant values. The lamp was two minutes off before every inrush current measurement was made.

Test voltage	230.0 V	
Frequency of the voltage	50.0 Hz	
Maximum inrush current	0.190 A	This current has been found at a voltage start angle of 80 degrees.
Pulse width of max inrush current	3.3E-4 s	This is the time that the pulse is higher than 10 % of the max inrush current.
Minimal inrush current	0.016 A	This current has been found at a voltage start angle of 0 degrees.
I^2 x t after 10 ms at 0 deg voltage start angle	0.000E+0 A	This is the I^2 t value when a zero crossing detector is used to start the voltage from 0 degrees.



Inrush current found at worst-case voltage start angle

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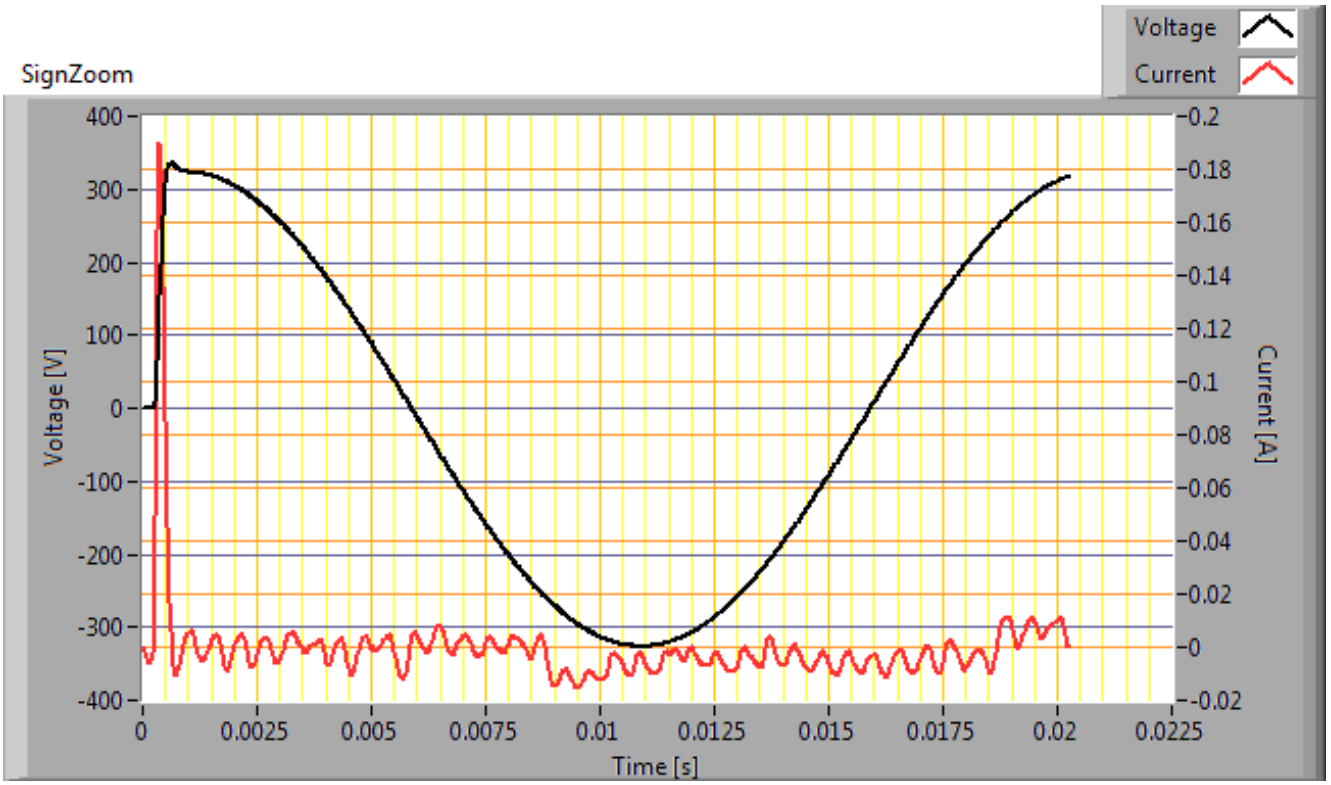
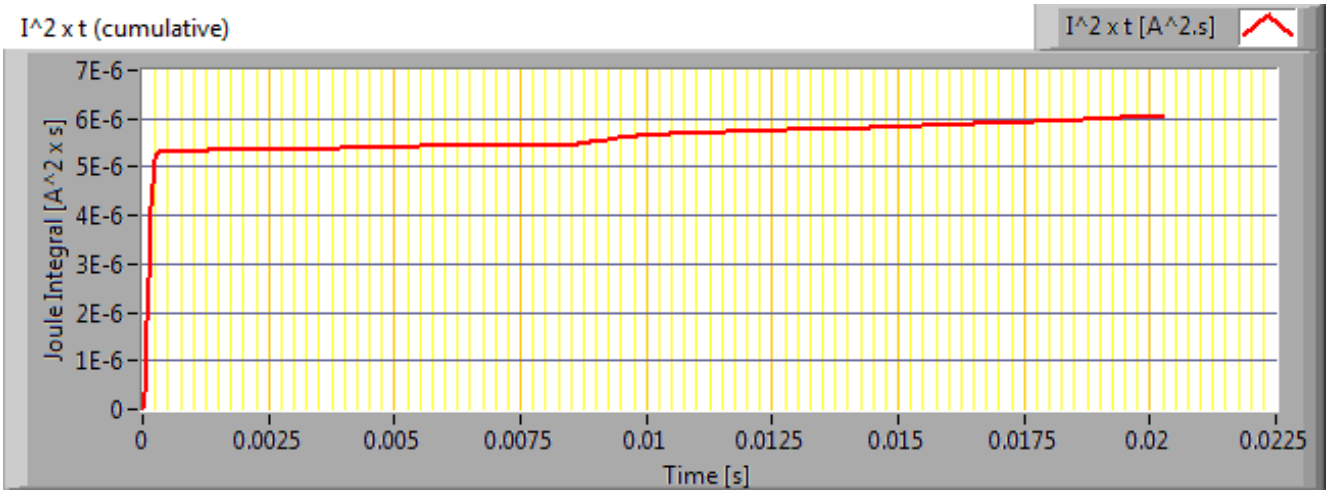


First cycle of the maximum inrush current



The energy I^2t during the first 10 ms of the first current cycle

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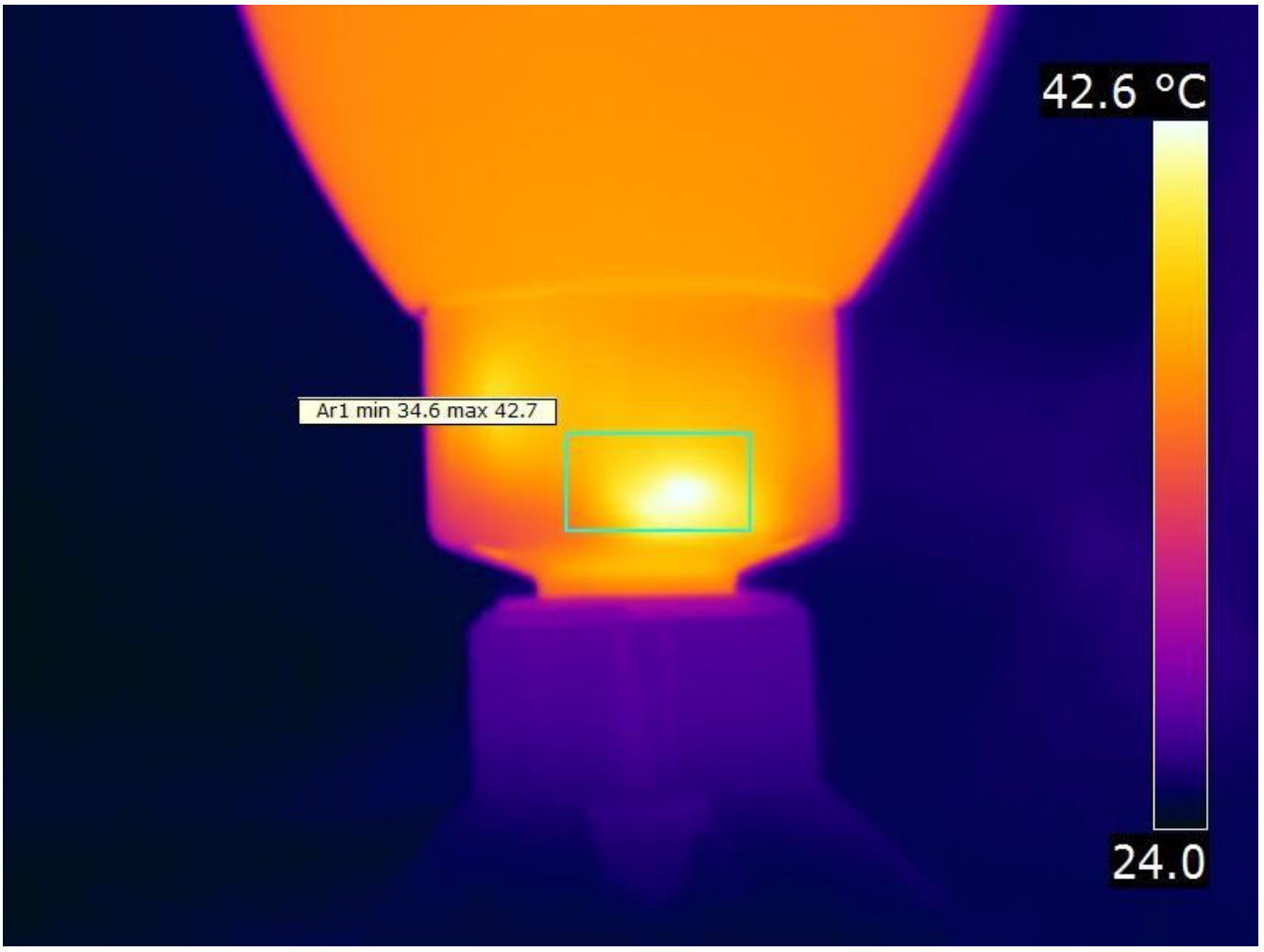
Temperature measurements lamp



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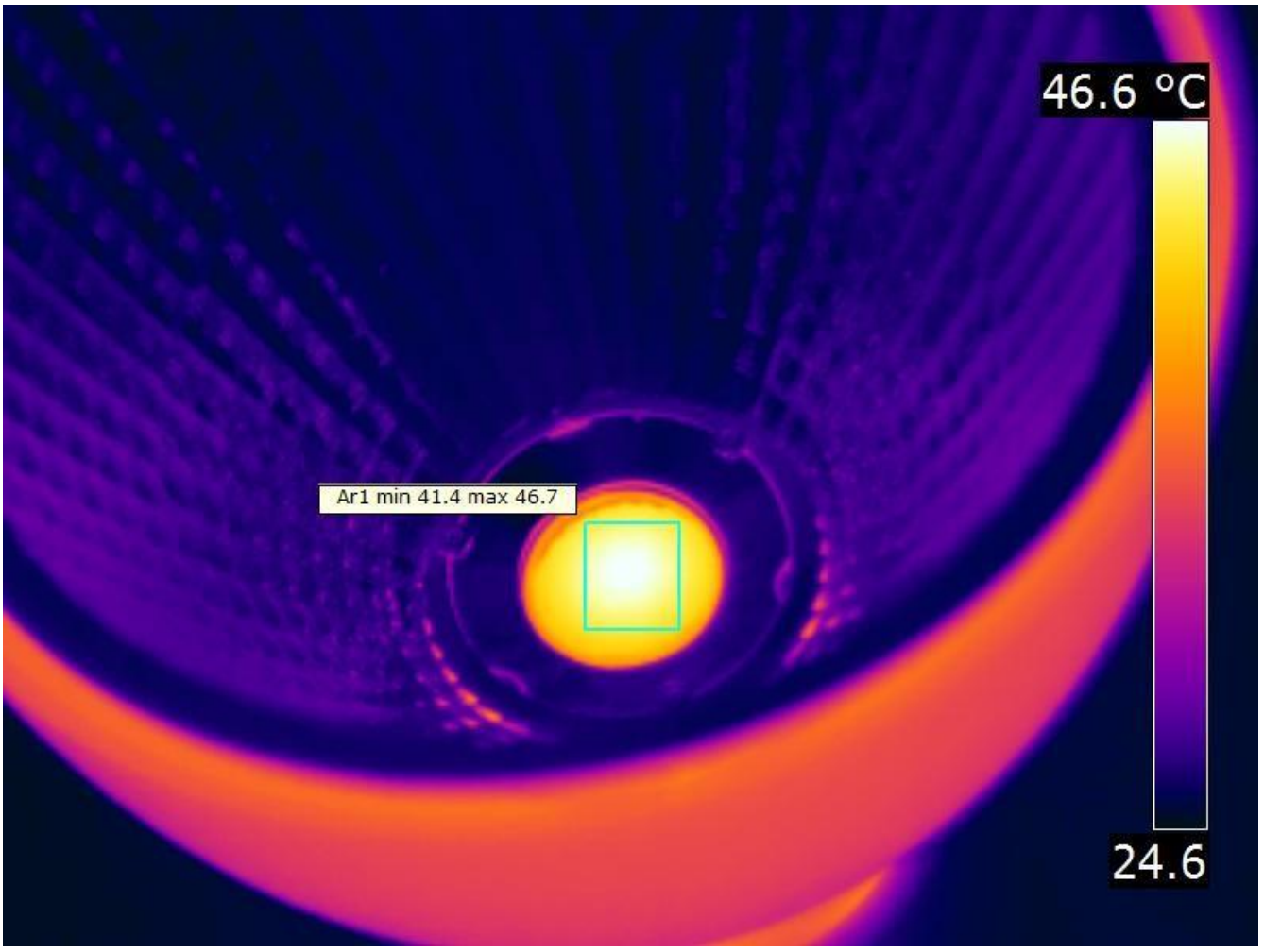

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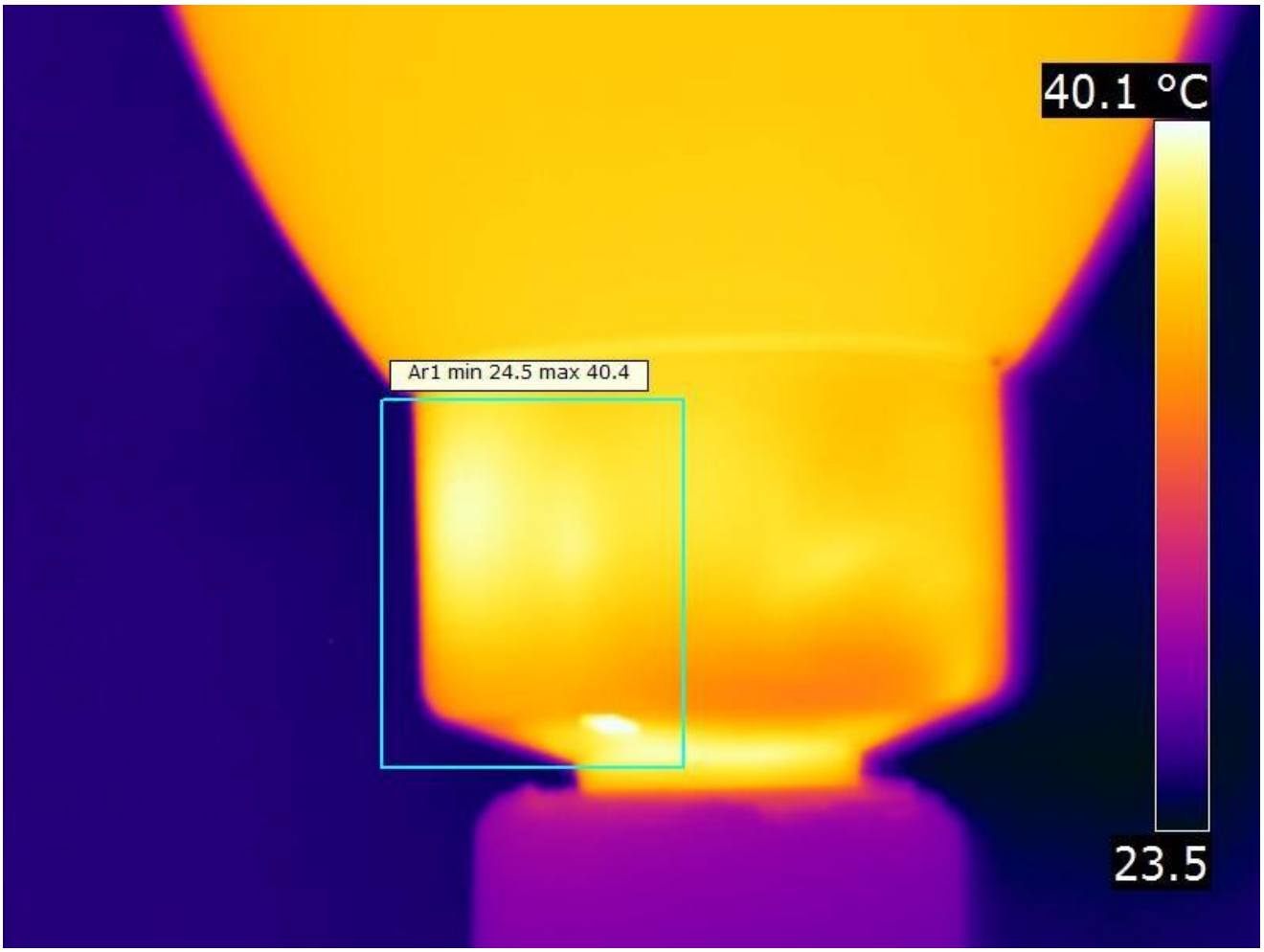

Temperature image(s).

status lamp	2 hours on
ambient temperature	25 deg C
reflected background temperature	25 deg C
camera	Flir T335
emissivity	0.95
measurement distance	0.5 m
IFOV_geometric	0.136 mm per 0.1 m distance
NETD (thermal sensitivity)	50 mK

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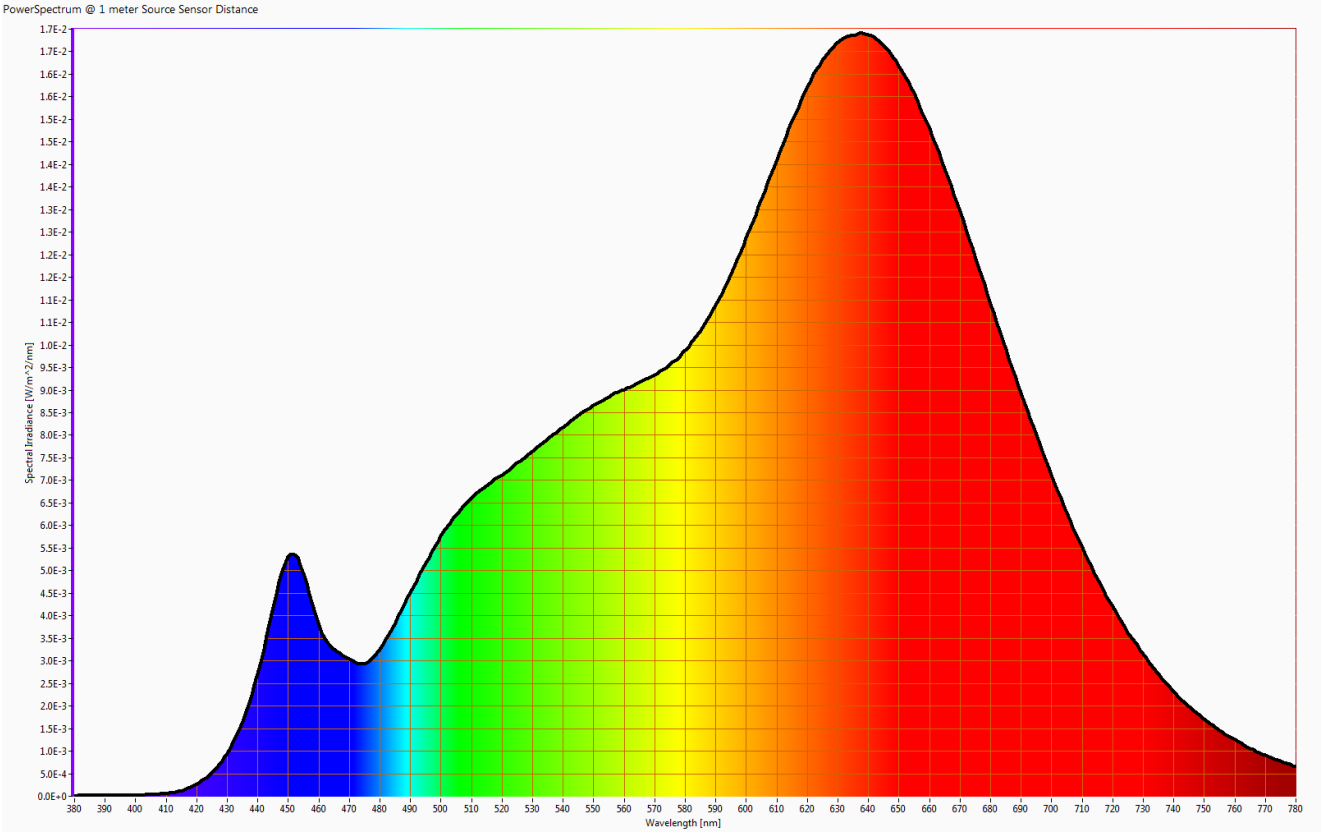
Color temperature and Spectral power distribution



The spectral power distribution of this light bulb, energies on y-axis valid at 1 m distance.

The measured color temperature is 2737 K which is warm white.

This color temperature is measured straight underneath the light bulb. Below a graph showing the color temperature for different inclination angles.

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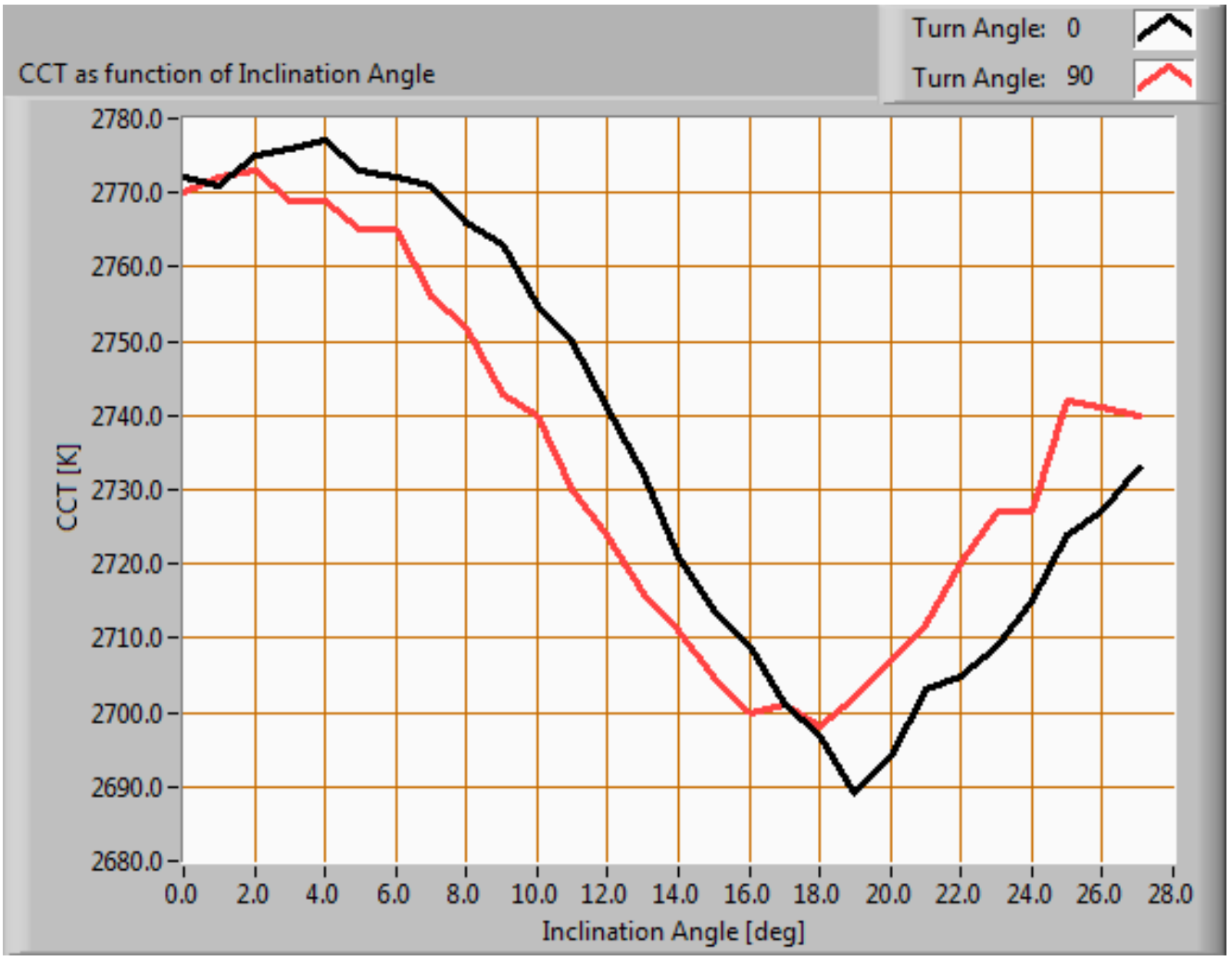

Color temperature as a function of inclination angle.

The color temperature is given for inclination angles up to 27 deg. Beyond that value the illuminance is lower than 10%% of Ev straight underneath the lamp, that it has not been used for color determination of the light.

For the C0-C180 plane: the beam angle of 24 deg is equivalent to 12.1 deg inclination angle,which is the area where most of the light falls within. The maximum variation of color temperature in this inclination area is about 2 %.

For the C90-C270 plane: the beam angle of 24 deg is equivalent to 12.1 deg inclination angle,which is the area where most of the light falls within. The maximum variation of color temperature in this inclination area is about 1 %.

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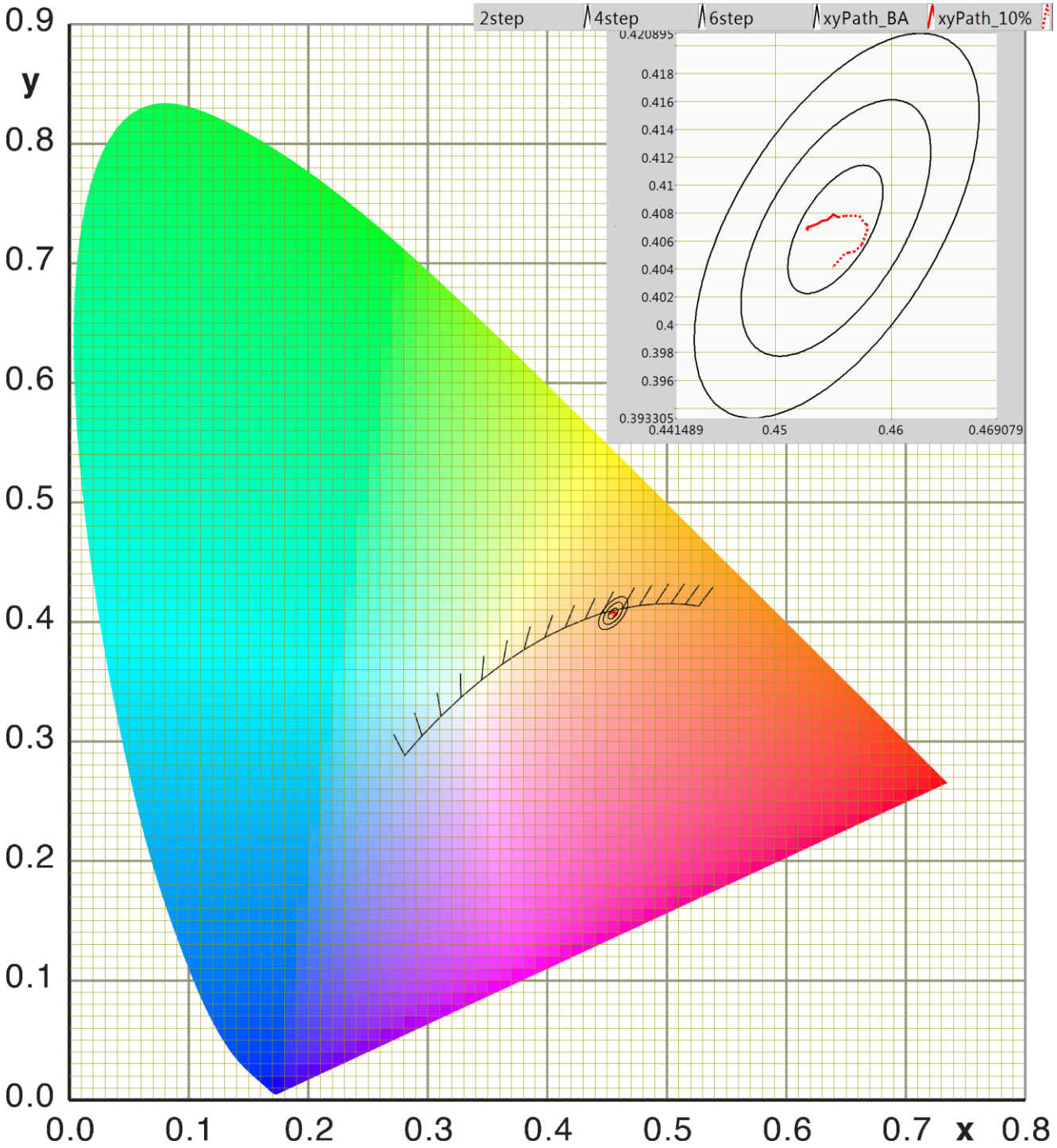

Color point dependent on inclination angle related to 2, 4 and 6 step MacAdam ellipse, for all angles within the beam angle (solid line) and for all angles where Ev dropped to 10 % value (dotted line)

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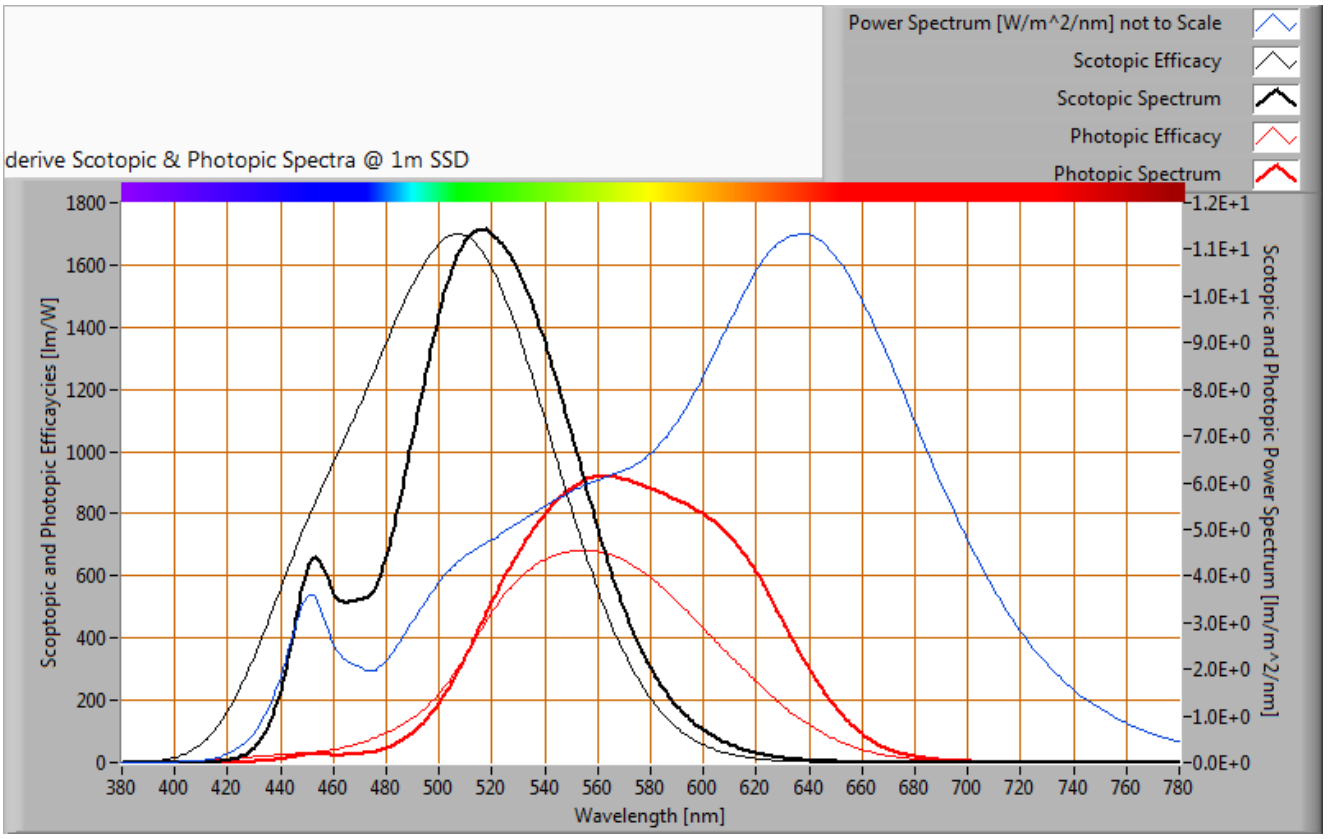
S/P ratio



The power spectrum, sensitivity curves and resulting scotopic and photopic spectra (spectra energy content defined at 1 m distance).

The S/P ratio of the light coming from this lamp is 1.4.

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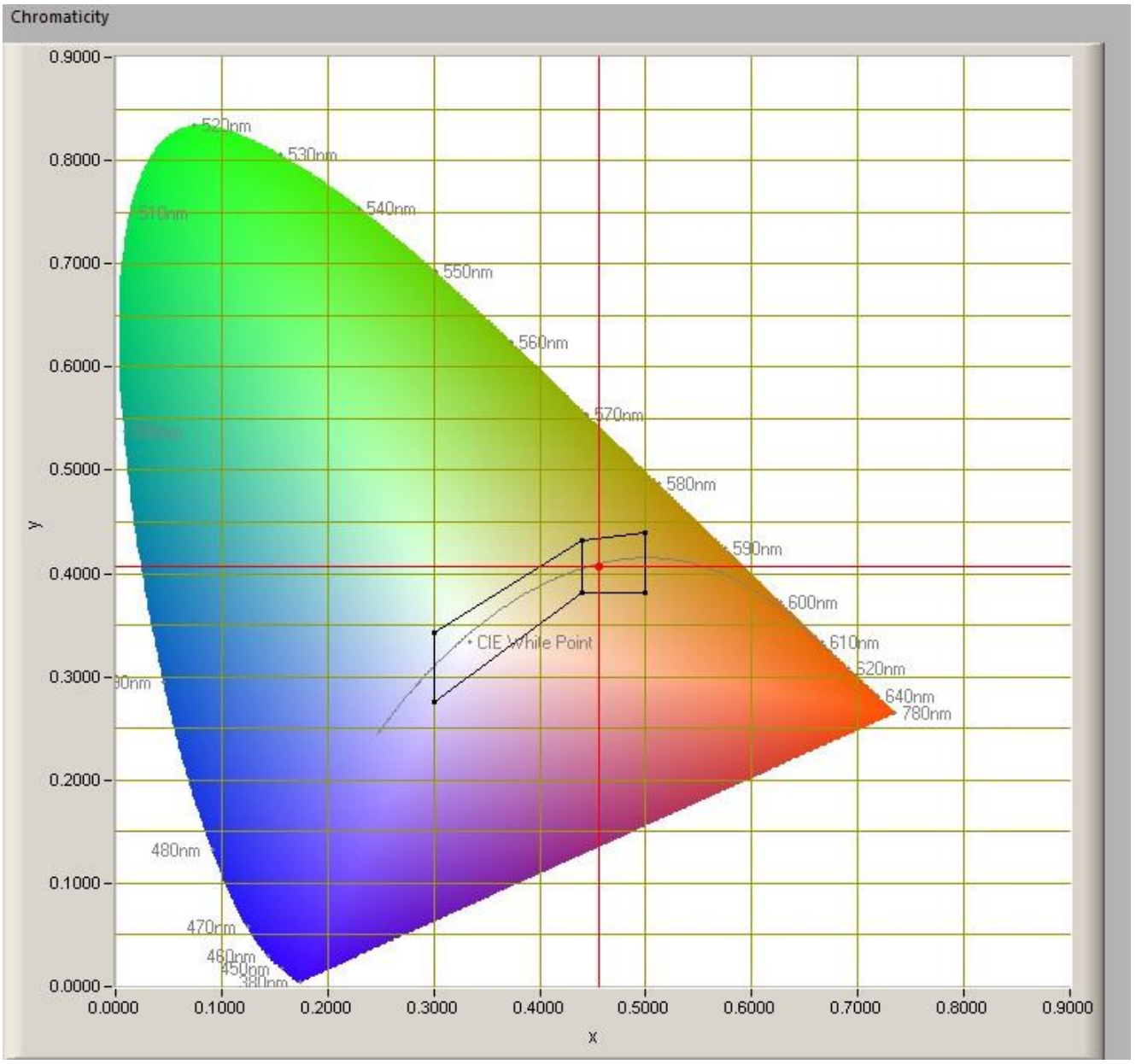
Chromaticity diagram



The chromaticity space and the position of the lamp's color coordinates in it.

The point of the light in this diagram is inside the area indicated with class B. The areas A and B indicate areas for signal lamps.

The color coordinates are x=0.4552 and y=0.4068.

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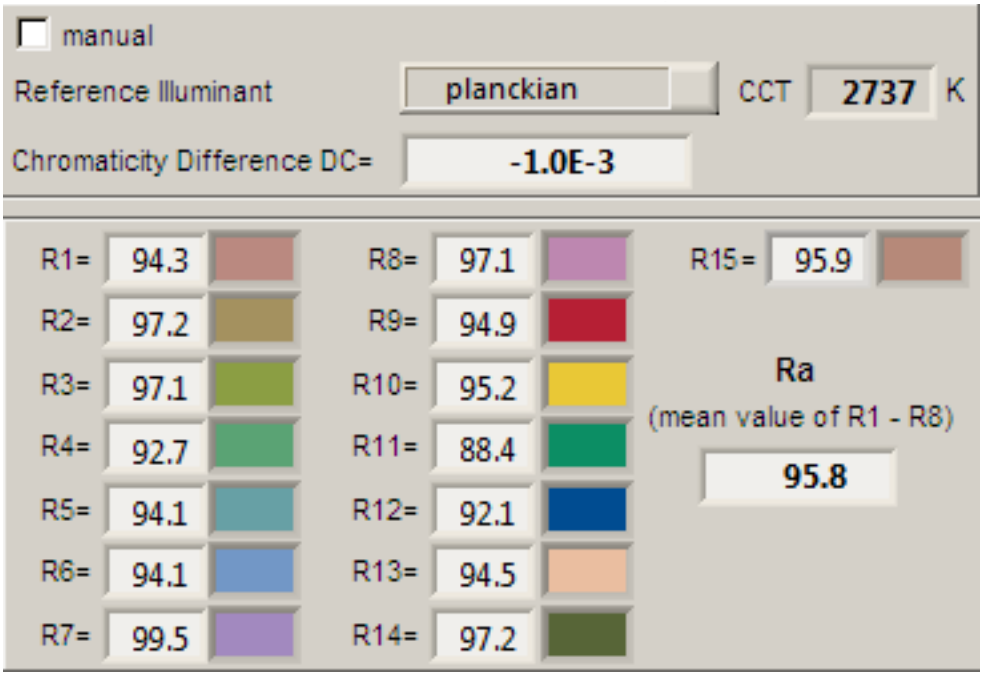
Color Rendering Index (CRI) or also Ra

Herewith the image showing the CRI as well as how well different colors are represented (rendered). The higher the number, the better the resemblance with the color when a black body radiator would have been used (the sun, or an incandescent lamp)

Each color has an index Rx, and the first 8 indexes (R1 .. R8) are averaged to compute the Ra which is equivalent to the CRI.



CRI of the light of this lightbulb.

This value of 96 indicates how well the light of this lamp can render well a set of reference colors, this in comparison with the light of a reference source (for color temperatures 5000K a black radiator is used as reference and for color temperatures 5000K the sun or the light outside during the day).

The value of 96 is much bigger than the value of 80 that is considered as a minimum for working areas in general.

Note: the chromaticity difference is -0.0010 and indicates the distance to the Planckian Locus. There is a value mentioned of max 5.4E-3 in section 5.3 of CIE 13.3-1995 however no further explanation of it.
An other reference with signal lights as a reference is given in the chromaticity diagram.

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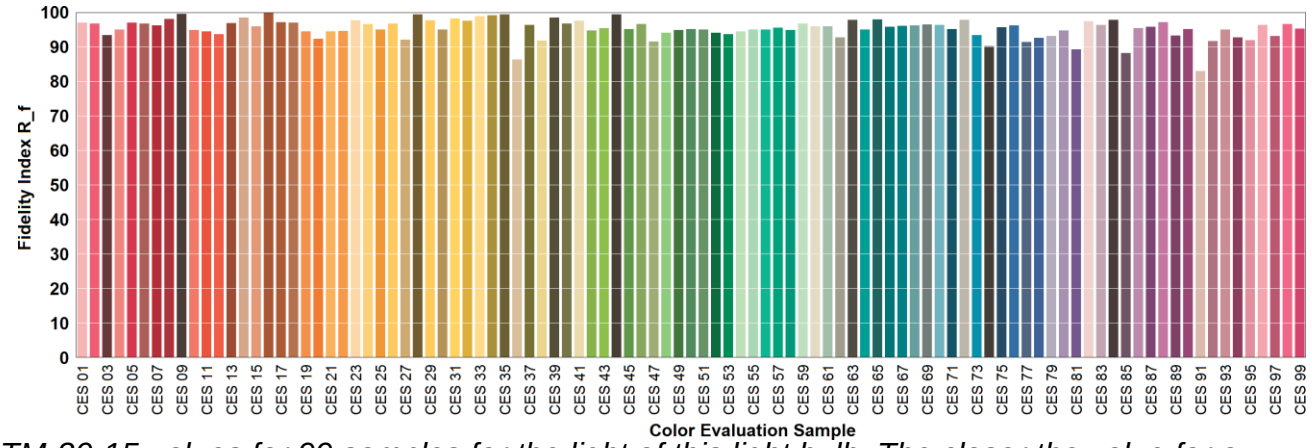
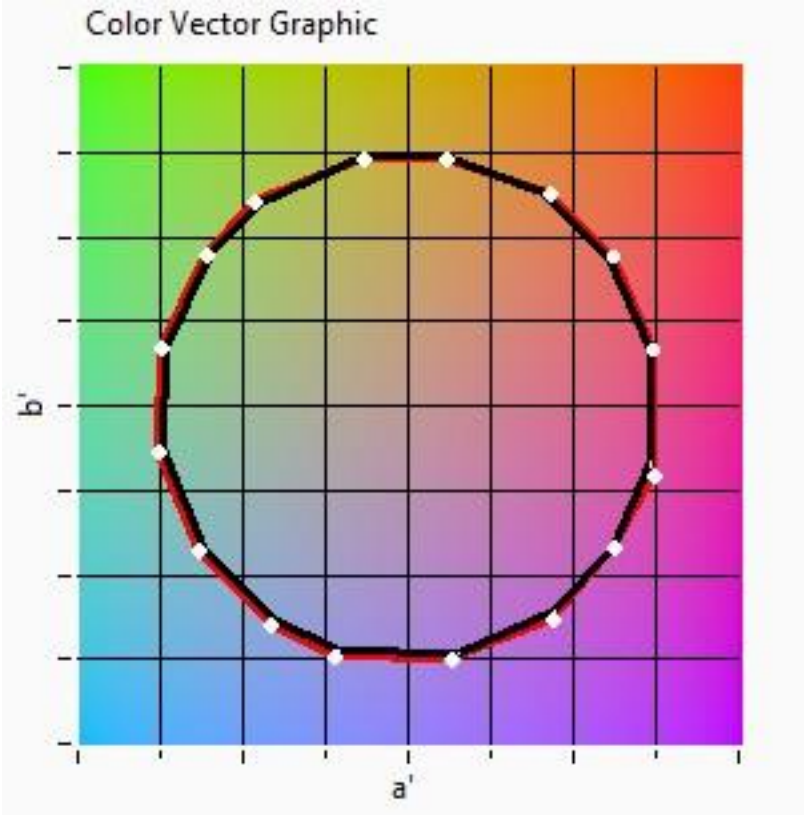
Color quality scale TM-30-15

TM-30-15 is an improved indicator (over CRI) of how well colors are rendered.
TM30-15 Rf = 95, Rg = 103.



TM-30-15-values for 99 samples for the light of this light bulb. The closer the value for a testcolor comes to 100, the more its rendition resembles that of a reference lightsource.



Graphical view of averaged color points for this light bulb compared to a reference source with the same color temperature.

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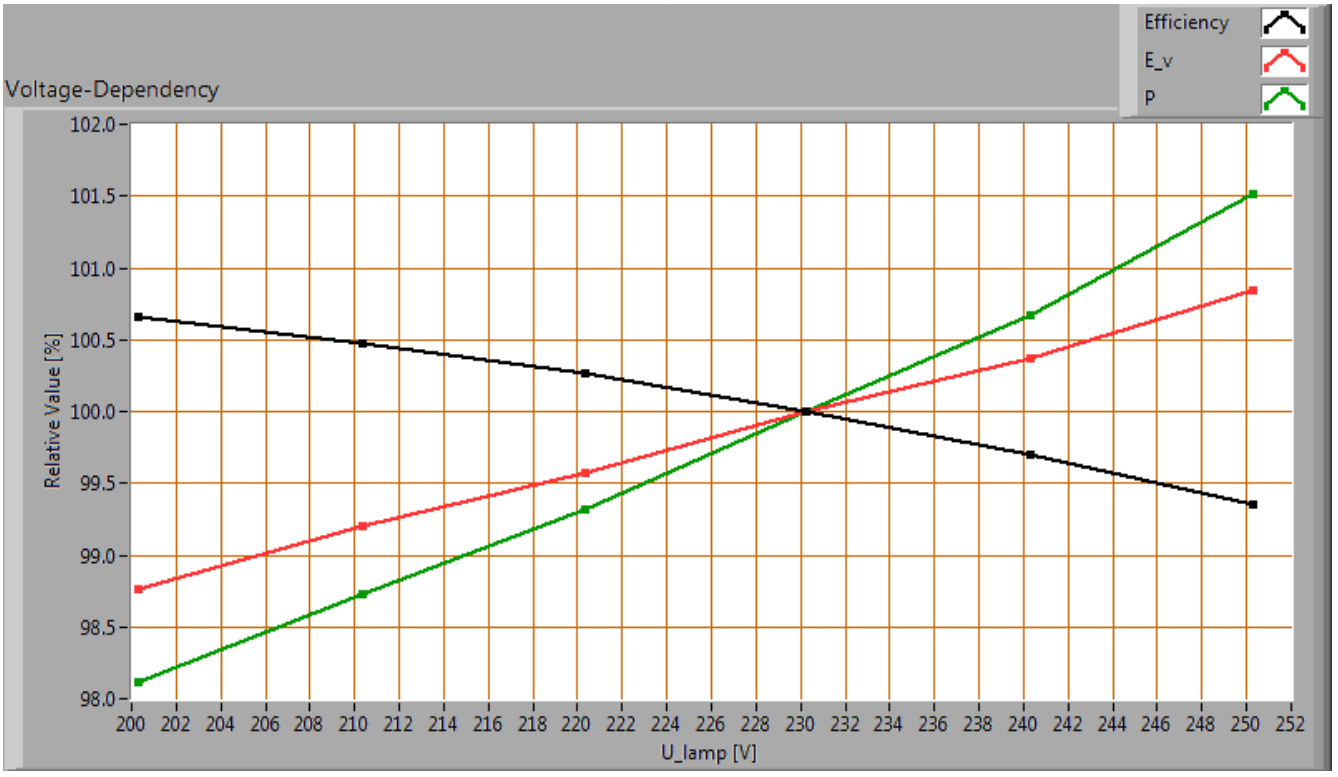
Voltage dependency

The dependency of a number of lamp parameters on the lamp voltage is determined. For this, the lamp voltage has been varied and its effect on the following light bulb parameters measured: illuminance E_v [lx], the lamppower P [W] and the luminous efficacy [lm/W] (this latter is estimated here by dividing the found E_v value by P).



Lamp voltage dependencies of certain light bulb parameters

There is no (significant) dependency of the illuminance when the power voltage varies between 200 - 250 V .
There is no (significant) dependency of the consumed power when the power voltage varies between 200 - 250 V .

When the voltage varies abruptly with + or - 5 V then this results in a variation of the illuminance of maximally 0.2 %. This difference in illuminance is not visible (when it occurs abruptly).

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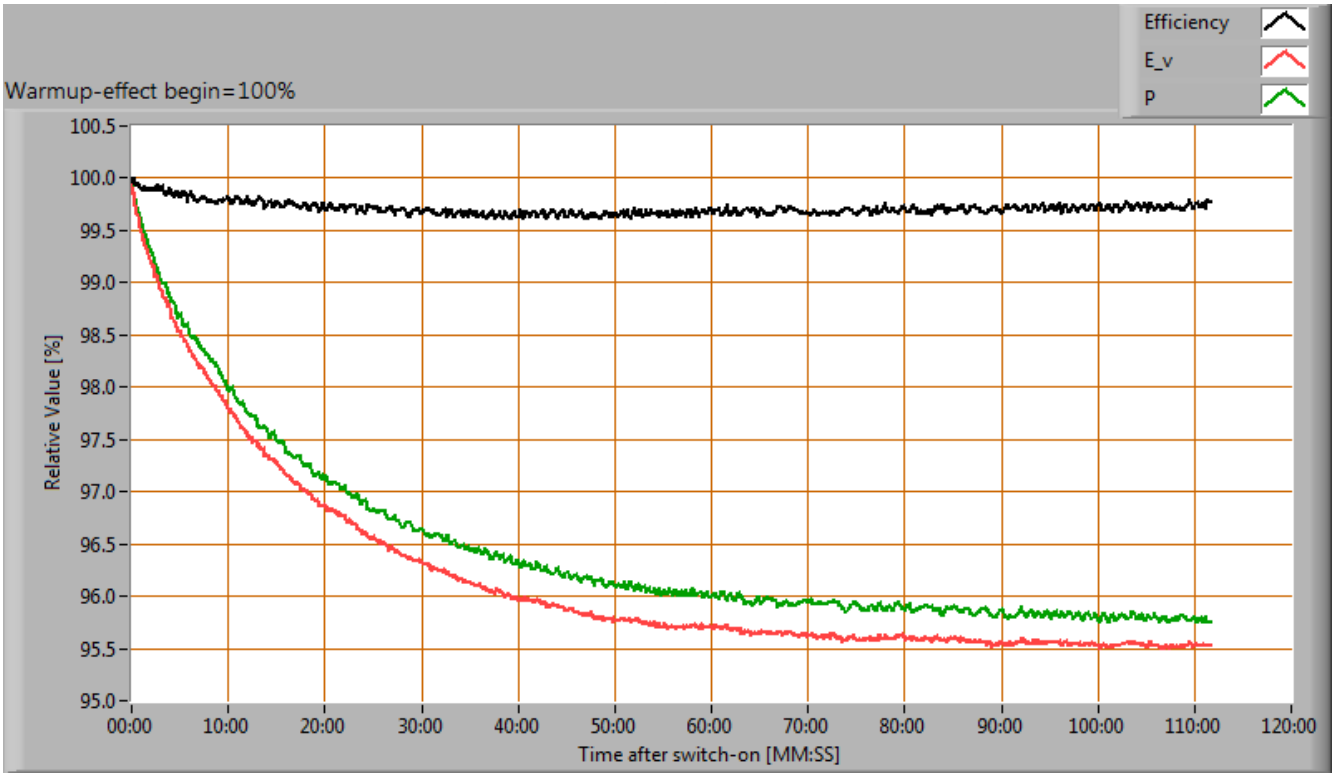
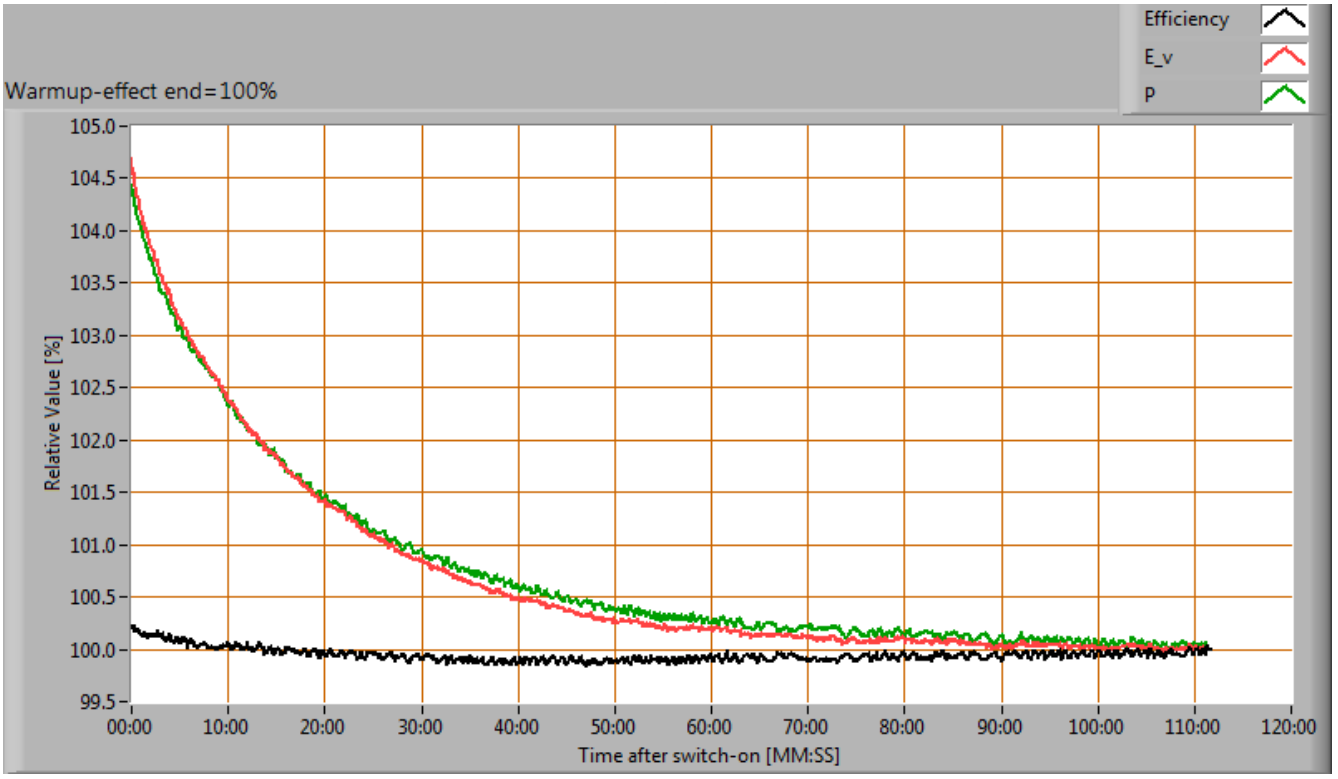
Warm up effects

After switch on of a cold lamp, the effect of heating up of the lamp is measured on illuminance E_v [lx], the lamppower P [W] and the luminous efficacy [lm/W].





Effect of warming up on different light bulb parameters. In the first graph the 100 % level is put at begin, and in the last graph the 100 % level is put at the end.

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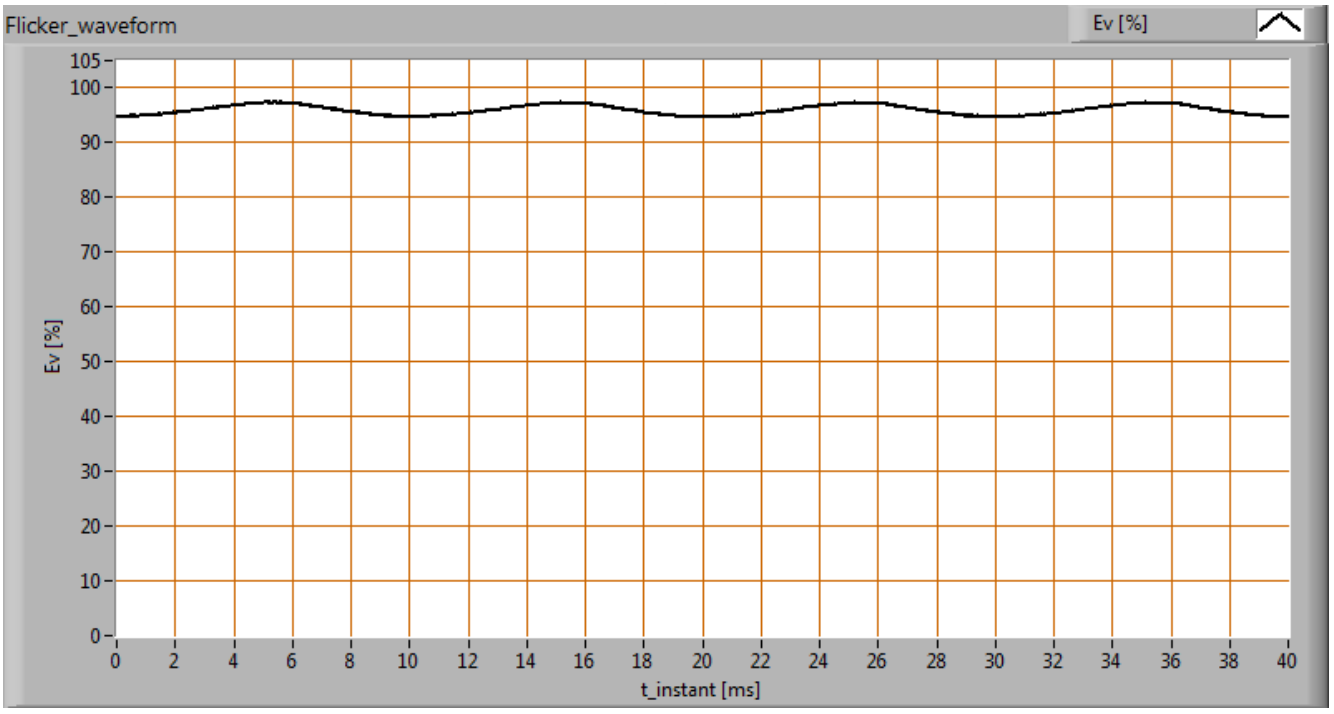
During the warmup time the illuminance doesn't vary significantly (5 %).

During the warmup time the power doesn't vary significantly (5 %).
The variation in efficacy (calculated as indication by simply dividing the illuminance by the power) during the warming up is -0 %. A very high negative value indicates a significant decrease for instance due to heating up of the lamp (decrease of lifetime).

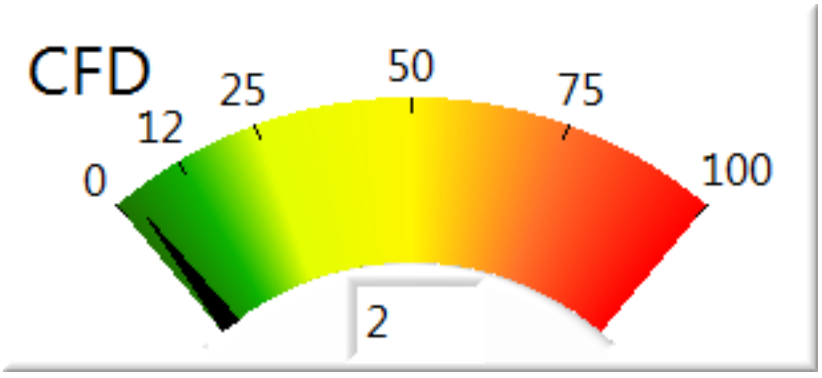
Measure of flickering

An analysis is done on the measure of flickering of the light output by this light bulb.



The measure of fast illuminance variation of the light of the light bulb

parameter	value	unit
Flicker frequency	99.8	Hz
Illuminance modulation index	2	%
Flicker index	0.004	[-]
SVM	0.0	[-]
Compact Flicker Degree	2	%



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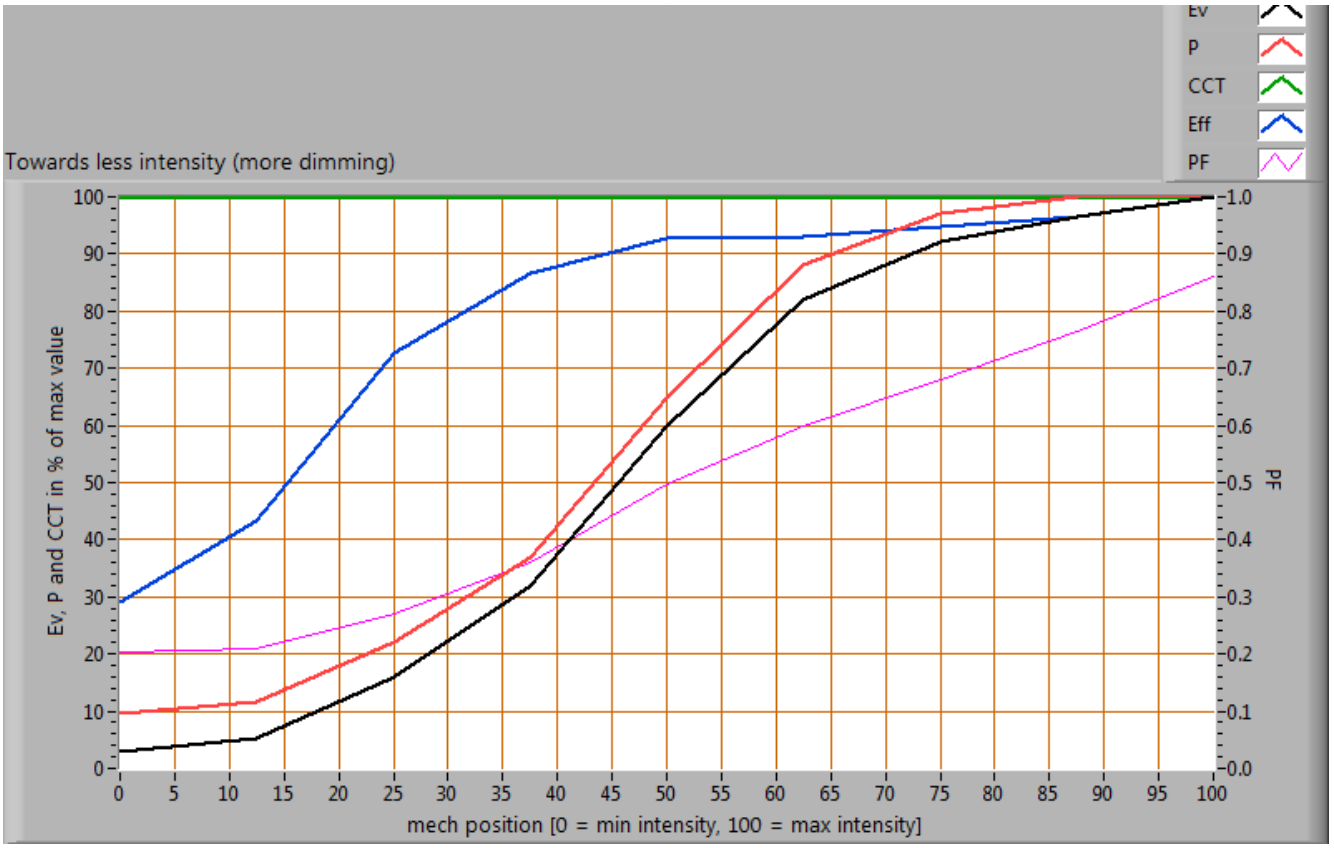
Imperceptible.

The illuminance modulation index is computed as: (max_Ev - min_Ev) / (max_Ev + min_Ev).

Dim-ability

The lamp has been tested on the following dimmer(s): the Busch Jaeger 6523 U, Busch Jaeger 6523 UR-103 pos RC min on pos min dimmer.

The Busch Jaeger 6523 U.



Dimming with the Busch Jaeger 6523 U.

When inserting the dimmer at its no dimming position and the comparing with the situation without dimmer, then the influence on the following parameters is measured (negative value is increase):
- the illuminance: 1 %;
- the consumed power: -3 %.

The intensity is variable in the mechanical area between 0.0 - 100.0 %.
The dimmer set in that area results in a variation of the illuminance between 3 - 100 % (note that in that 100 % the drop in illuminance when inserting the dimmer is not counted, see for that value above).

There is no effect on the color temperature when dimming is increased.

The remaining power consumption at maximal dimming position is 0.8 W.

The Busch Jaeger 6523 UR-103.

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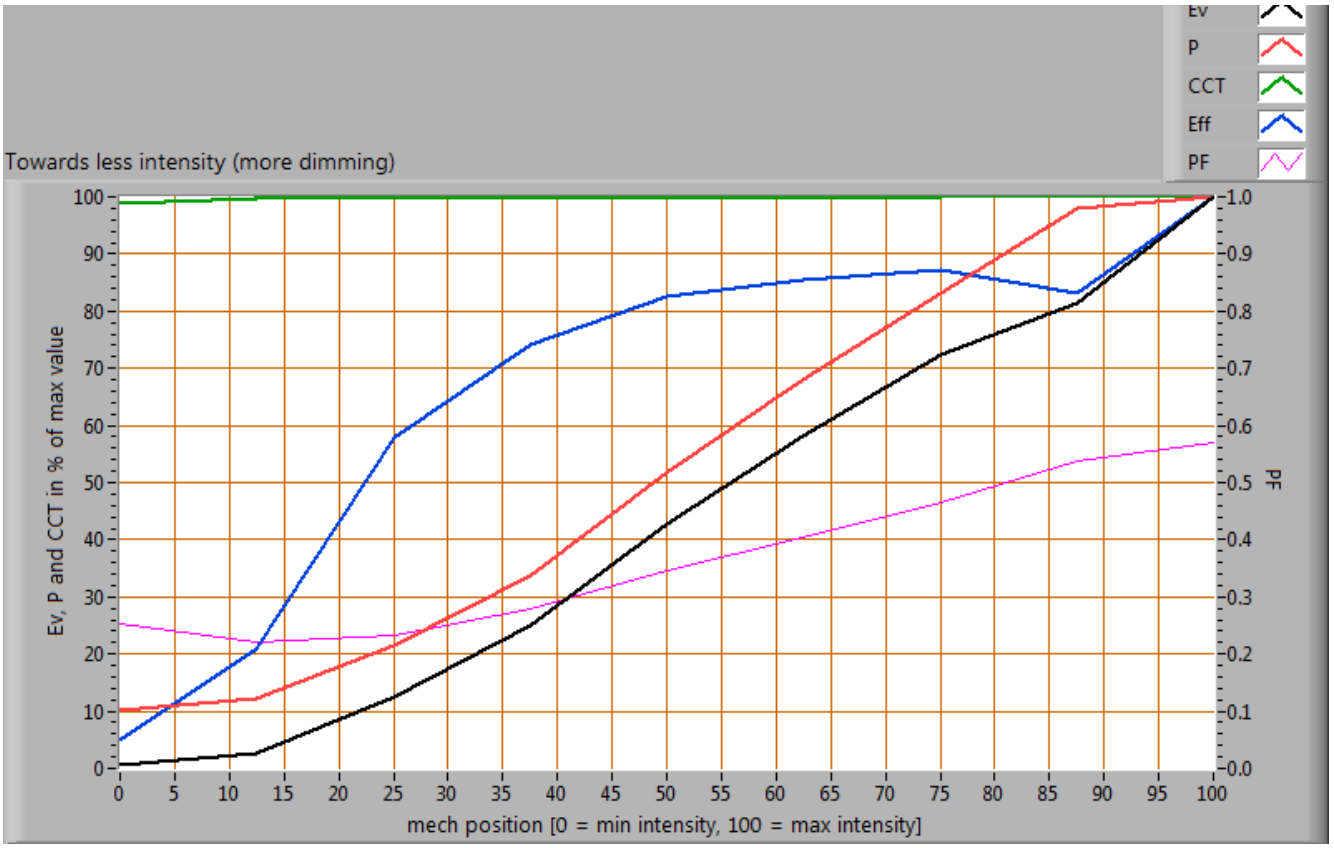

Dimming with the Busch Jaeger 6523 UR-103.

When inserting the dimmer at its no dimming position and the comparing with the situation without dimmer, then the influence on the following parameters is measured (negative value is increase):
- the illuminance: 1 %;
- the consumed power: 3 %.

The intensity is variable in the mechanical area between 0.0 - 100.0 %.
The dimmer set in that area results in a variation of the illuminance between 0 - 100 % (note that in that 100 % the drop in illuminance when inserting the dimmer is not counted, see for that value above).

There is almost no effect on the color temperature when dimming is increased.

The remaining power consumption at maximal dimming position is 0.8 W.

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Melanopic effect

The melanopic effect shows the level of impact the light of this lamp can have on the day-night rhythm of human beings (as well as the suppression of melatonin production). The important parameters (according to norm DIN SPEC 5031-100:2015-08):

melanopic effect factor	0.436
k_mel trans (25 years)	1.041
k_mel trans (32 years)	1.000
k_mel trans (50 years)	0.866
k_mel trans(75 years)	0.651
k_mel trans(90 years)	0.528
k_pupil(25 years)	1.088
k_pupil(32 years)	1.000
k_pupil(50 years)	0.792
k_pupil(75 years)	0.543
k_pupil(90 years)	0.416

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Circadian Stimulus (CS)

The circadian stimulus indicates the degree of influence that the light of this lamp has on the human circadian rhythm. In addition to the melanopic effect of Ganglion cells, the contributions of S-cones and rods are also included. A CS value of 0.1 has hardly any effect and a value > 0.3 has an effect (0.7 is the maximum, saturated, value). The CS value depends on the spectrum of the light and also on the amount of it (received on the eye).

Ev [lux]	CL__A	CS
20.0	19.3	0.03
30.0	28.9	0.04
50.0	48.2	0.07
75.0	72.3	0.10
100.0	96.4	0.13
150.0	144.6	0.19
300.0	289.3	0.31
500.0	482.1	0.41
750.0	723.2	0.48
1000.0	964.3	0.53
1500.0	1446.4	0.58
2000.0	1928.5	0.61

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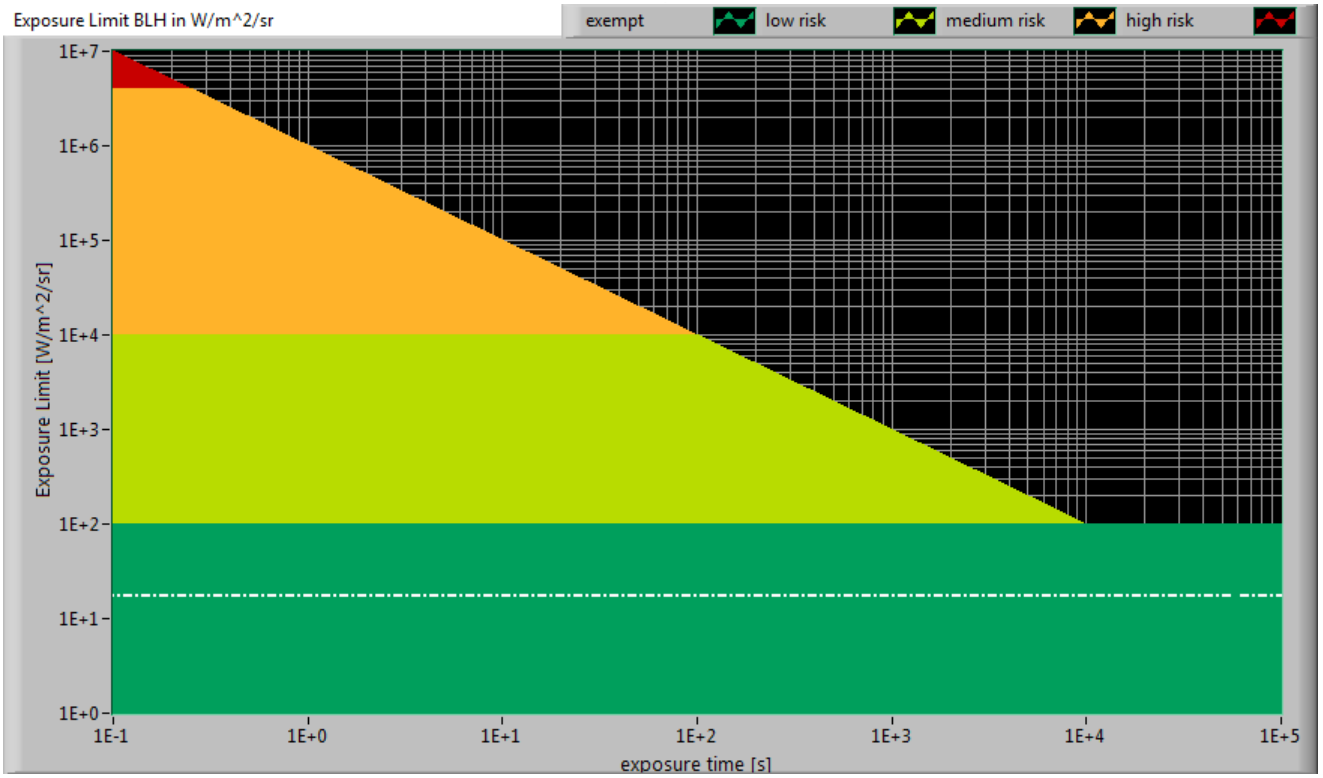
Blue Light Hazard

The amount of blue light and the harm it can cause on the retina has been determined. Herewith the results.



The level of blue light of this lamp related to the exposure limit and the different classification areas.

L_lum0 [mm]	100	Dimension of brightest part of lamp in C0-C180 direction.
L_lum90 [mm]	100	Dimension of brightest part of lamp in C90-C270 direction.
SSD_500lx [mm]	2277	Calculated distance where Ev = 500 lux. This computation is valid when it is in the far field of the lamp. Note: if this value 200 mm then the distance of 200 mm is taken as proposed in the norm IEC 62471:2006.
Start of far field [mm]	707	Minimum distance at which the lamp can be seen as a point source. In this area the Ev is linearly dependent from (1/distance)^2.
300-350 nm values stuffed with 0s	no	In the event OliNo has measured with a SpB1211 spectrometer without UV option then the irradiance data of 300-349 nm is missing. For lamps where there is already no energy content near 350 nm, the values 300-349 can also be set at zero then.
alpha_C0-C180 [rad]	0.100	(Apparent) source angle in C0-C180 direction.
alpha_C90-C270 [rad]	0.100	(Apparent) source angle in C90-C270 direction.

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alpha_AVG [rad]	0.100	Average (apparent) source angle. If average >= 0.011 rad then the exposure limit is computed with radiance Lb. Otherwise with irradiance Eb.
Exposure value [W/m^2/sr]	1.72E+1	Blue Light Hazard value for this lamp, measured straight underneath the lamp. Computation is referenced to Lb.
Blue Light Hazard risk group	0	0=exempt, 1=low, 2 = moderate, 3=high risk.

Extra

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Additional photos.

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