

Lamp measurement report – 4 April 2010

2x120cm led tube in built-in luminaire
by
Luminesense



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Summary measurement data

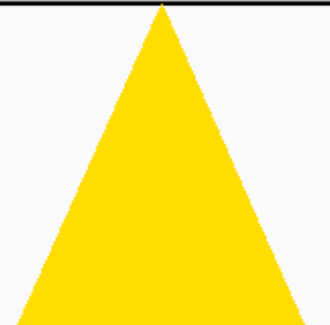
parameter	meas. result	remark
Color temperature	4217 K	Neutral white
Luminous intensity I_v	1097 Cd	Measured straight underneath the lamp
Illumination modulation index	20 %	Measured straight underneath the lamp. Is a measure for the amount of flickering.
Beam angle	101 deg	101° for the C0-C180 plane (crossing length direction of the tube) and 100° for the C90-C270 plane (length direction). This is virtually the same value.
Power P	49.1 W	
Power Factor	0.95	For every 1 kWh net power consumed, there has been 0.3 kVAhr for reactive power.
THD	10 %	Total Harmonic Distortion
Luminous flux	3140 Lm	
Luminous efficacy	64 Lm/W	
CRI_Ra	72	Color Rendering Index.
Coordinates chromaticity diagram	x=0.3721 and y=0.3751	
Fitting	FL-tube	This Tube Light is connected directly to the grid voltage of 230 V AC.
PAR-value	9.6 $\mu\text{Mol/s/m}^2$	The number of photons seen by an average plant when it is lit by the light of this light bulb. Value valid at 1 m distance from light bulb.
PAR-photon efficacy	0.6 $\mu\text{Mol/s/W}_e$	The total emitted number of photons by this light, divided by its consumption in W. It indicates a kind of efficacy in generating photons.

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S/P ratio	1.6	This factor indicates the amount of times more efficient the light of this light bulb is perceived under scotopic circumstances (low environmental light level).
L x W x H external dimensions	1195 x 295 x 97 mm	External dimensions of the lamp.
L x W luminous area	1150 x 250 mm	Dimensions of the luminous area (used in Eulumdat file). This is equal to the total of openings of the reflector at the front behind which the two led tubes are situated.
General remarks		<p>The ambient temperature during the whole set of measurements was 24.5 deg C. The temperature of the lamp gets about 14 degrees hotter than ambient.</p> <p>Warm up effect: during the warm up time the illuminance decreased with 7 % and the consumed power with 4 %.</p> <p>Voltage dependency: the power consumption and illuminance do not vary significantly when the voltage is varied from 200 - 250 V.</p>

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Overview table

m.	Ø 50%		C0-180: 101° C90-270: 100° 	E (lux)	Luminaire Efficacy
	C0-180	C90-270			64 (lumens per Watt)
0.25	0.61	0.59		17548	Half-peak diam C0-180
0.5	1.22	1.18		4387	2.43 x diameter(m)
1	2.43	2.37		1097	Half-peak diam C90-270
1.5	3.65	3.55		487	2.37 x diameter(m)
3	7.3	7.1		122	Illuminance
4	9.73	9.47		69	1097 / distance² (lux)
5	12.16	11.83		44	Total Output
					3140 (lumens)

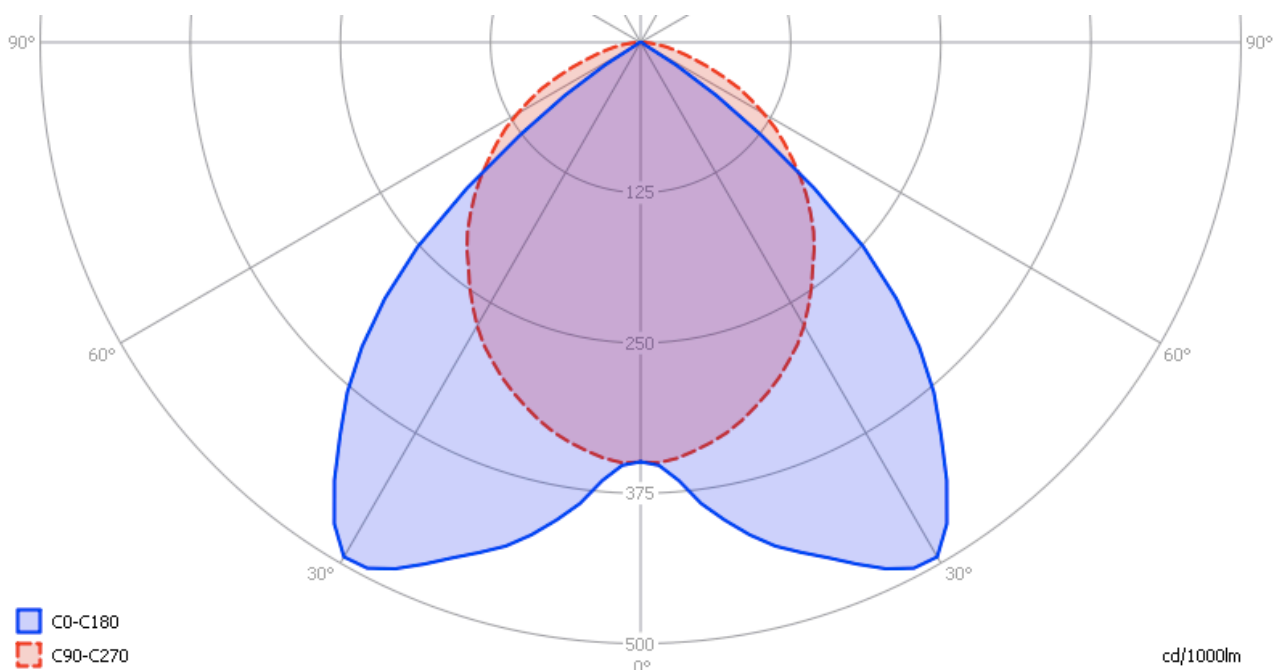
The overview table is explained on the OLiNo website.

Please note that this overview table makes use of calculations, use this data with care as explained on the OLiNo site. E (lux) values are not accurate, when within 5 x 1150 mm ≈ 5800 mm. Within this distance from the lamp, the measured lux values will be less than the computed values in this overview as the measurements are then within the near field of the lamp.

Eulumdat light diagram

This light diagram below comes from the program Qlumedit, that extracts these diagrams from an Eulumdat file. It is explained on the OLiNo site.

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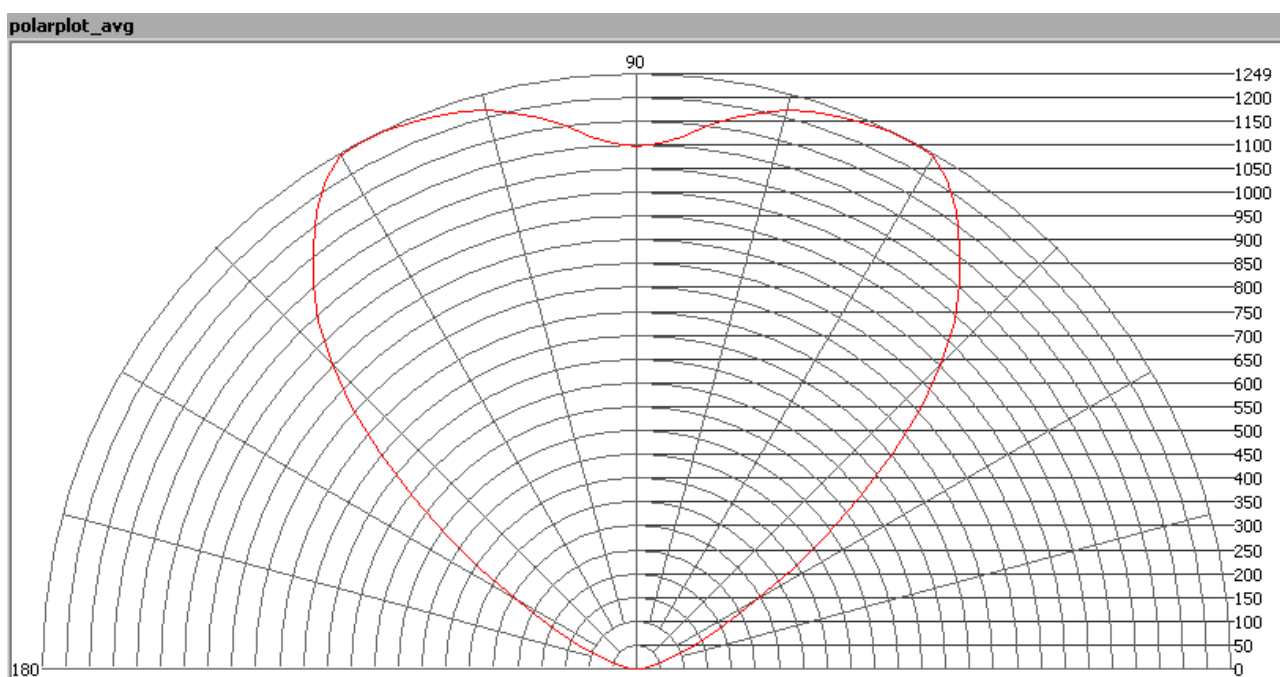
The light diagram giving the radiation pattern.

It indicates the luminous intensity around the light bulb. The direction or plane C90-C270 (along the length direction of the tube) emits a lot less light to the sides than does the C0-C180 (crossing the length direction of the tube).

Illuminance E_v at 1 m distance, or luminous intensity I_v

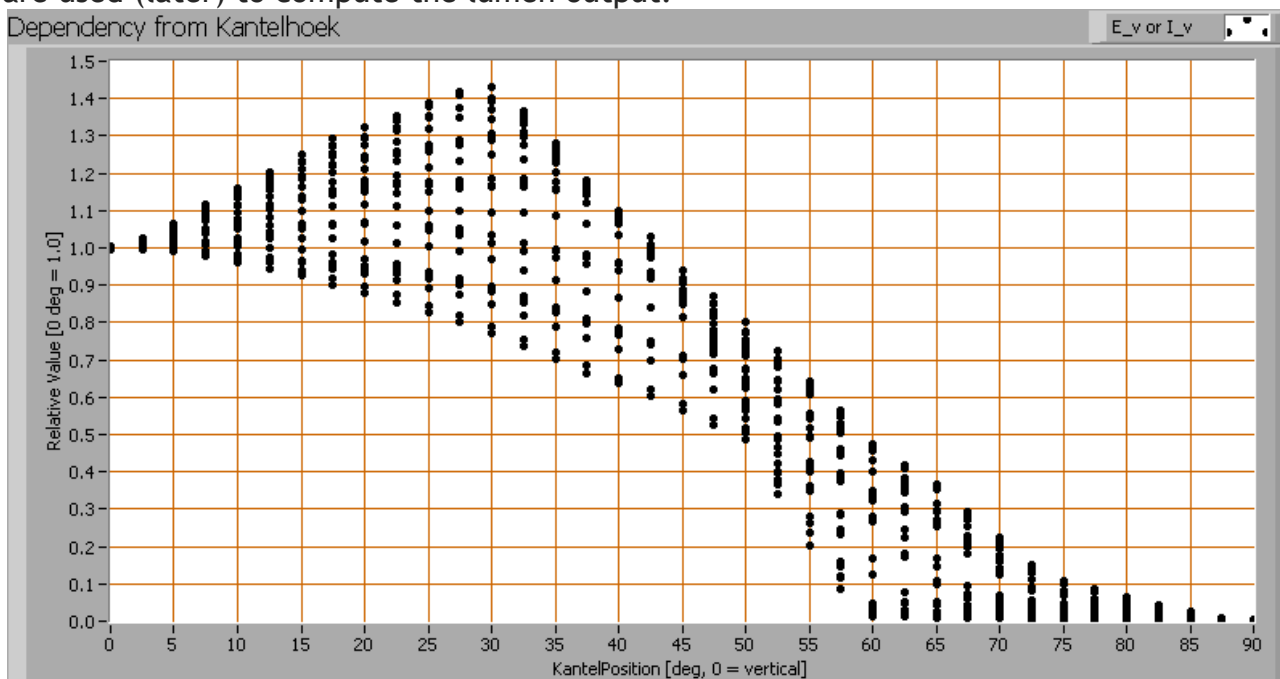
Herewith the plot of the *averaged* luminous intensity I_v as a function of the inclination angle with the light bulb.

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The radiation pattern of the light bulb.

This radiation pattern is the average of the light output of the light diagram given earlier. Also, in this graph the luminous intensity is given in Cd. These averaged values are used (later) to compute the lumen output.



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



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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. When using the average values per inclination angle, the beam angle can be computed, being 100-101° depending on the plane looked at (resp. the C90-C270 plane and the C0-C180 plane).

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 3140 Lm.

Luminous efficacy

The luminous flux being 3140 Lm, and the power of the light bulb being 49.1 W, yields a luminous efficacy of 64 Lm/W.

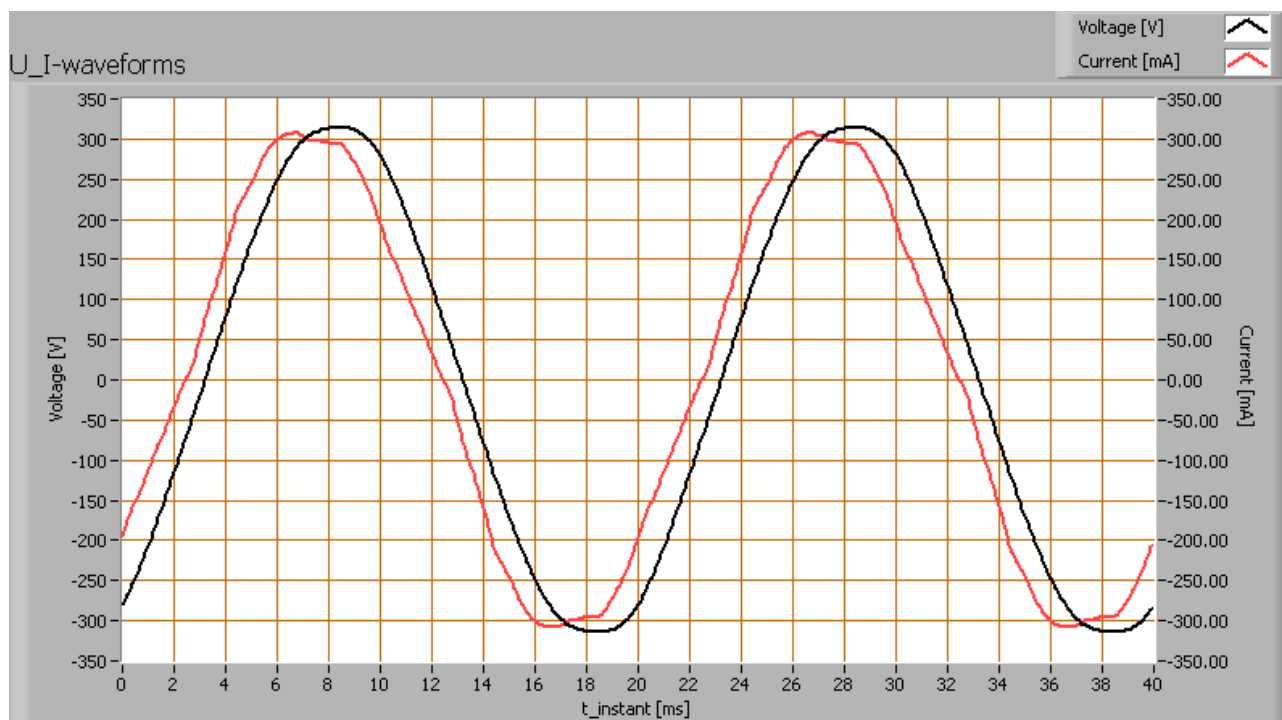
Electrical properties

A power factor of 0.95 means that for every 1 kWh net power consumed, a reactive component of 0.3 kVAr was needed.

Lamp voltage	230 VAC
Lamp current	224 mA
Power P	49.1 W
Apparent power S	51.6 VA
Power factor	0.95

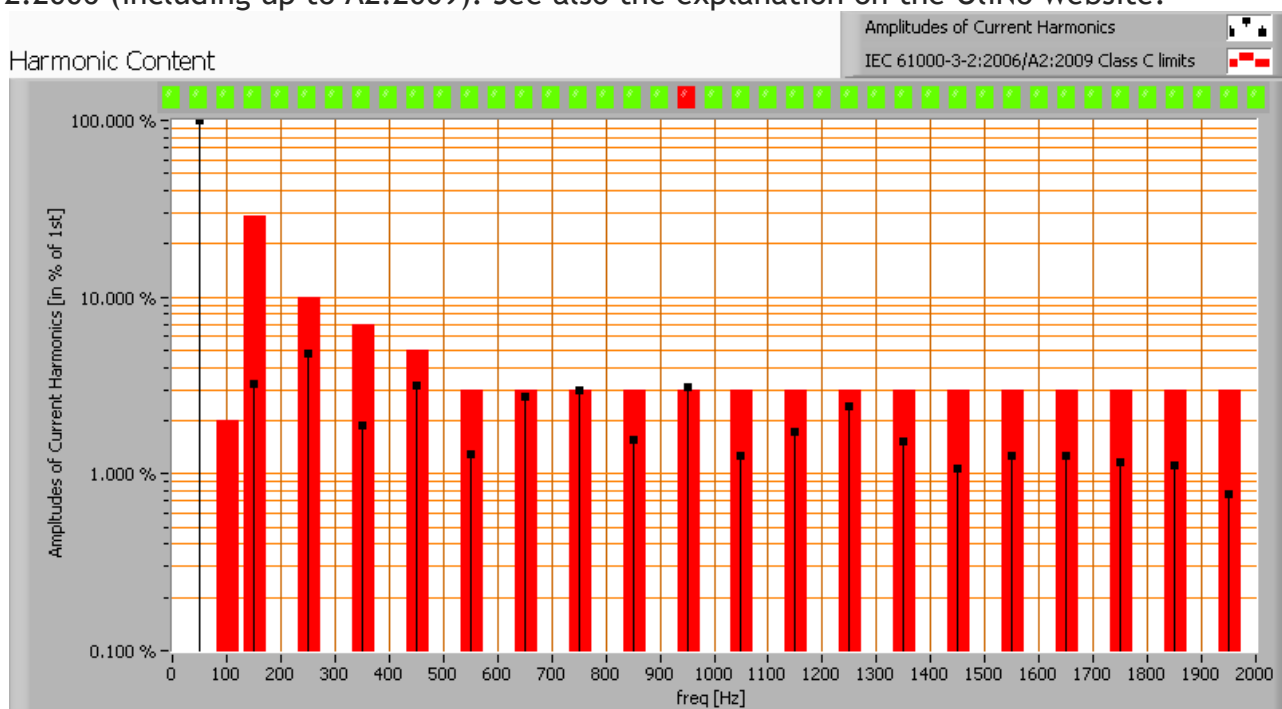
Of this light bulb the voltage across and the resulting current through it are measured and graphed. See the OLiNo site how this is obtained.

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Voltage across and current through the lightbulb

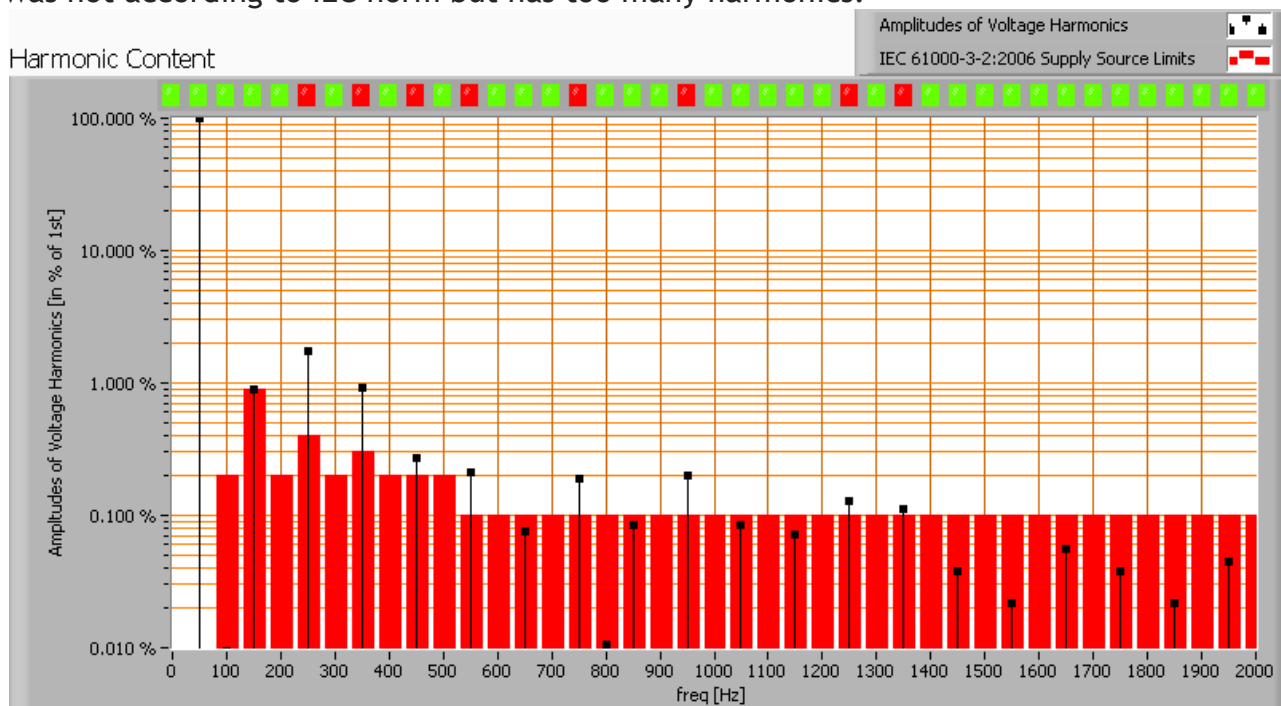
This waveforms have been checked on requirements posed by the norm IEC 61000-3-2:2006 (including up to A2:2009). See also the explanation on the OLiNo website.



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Harmonics in the current waveform and checked against IEC61000-3-2:2006

There are limits for the harmonics for lighting equipment > 25 W. This result shows that for one frequency it is beyond the limit. However this can be because the used voltage was not according to IEC norm but has too many harmonics.



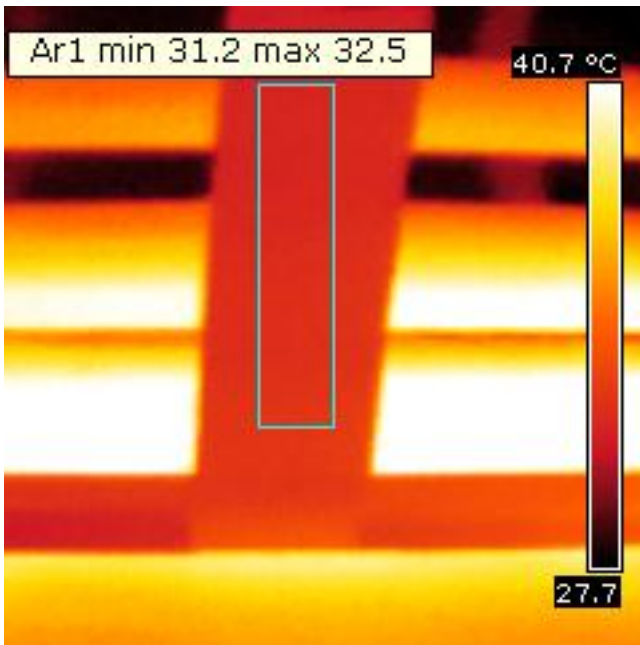
Harmonics in the used lamp voltage

As the lamp unit has only slightly more harmonics than the norm prescribes, and as the used voltage is not fulfilling the norm's limits on harmonics but goes beyond, it is assumed that the lamp unit might very well stay within the IEC harmonic content limits if a clean enough voltage was used. Therefore the result shown should be considered as an indicator.

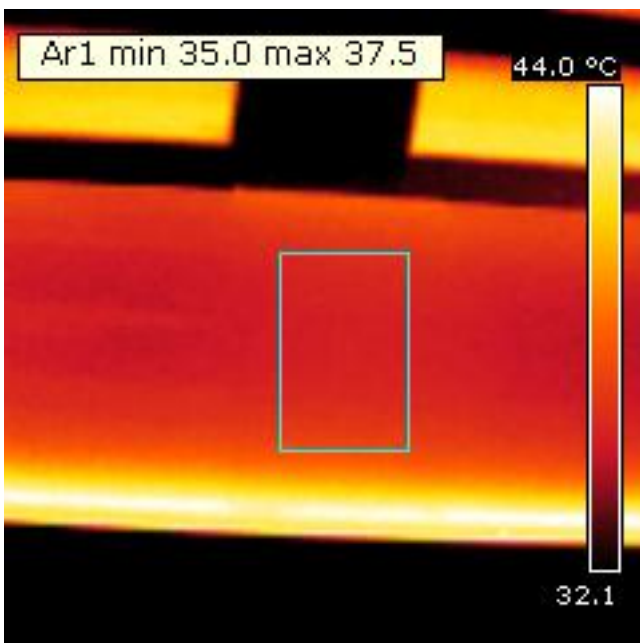
The Total Harmonic Distortion of the current is computed as 10 %.

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Temperature measurements lamp



Temperature image of the reflector, measured on masking tape



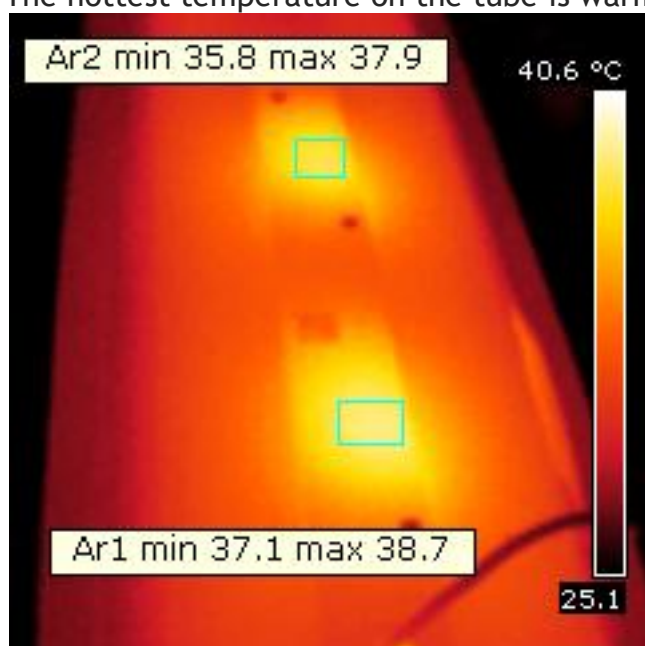
Hottest spot on the tube itself, measured on masking tape

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status lamp	> 2 hours on
ambient temperature	24 deg C
reflected background temperature	24 deg C
camera	Flir BCAM
emissivity	0.95 ⁽¹⁾
measurement distance	0.20 m
IFOV _{geometric}	0.7 mm
NETD (thermal sensitivity)	100 mK

⁽¹⁾ The emissivity is set at 0.95 which is close to the value of the masking tape that was used.

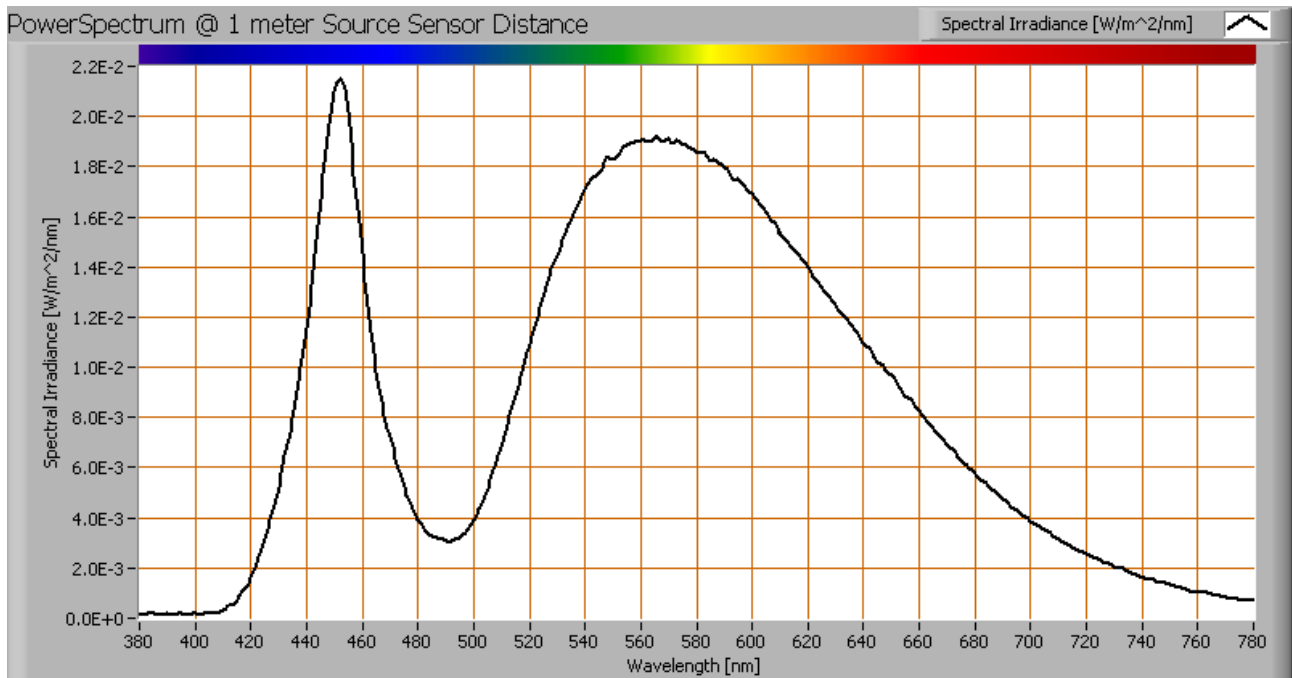
The hottest temperature on the tube is warm-to-the-touch.



Back side the power supply unit is well visible, leaving hot marks

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Color temperature and Spectral power distribution

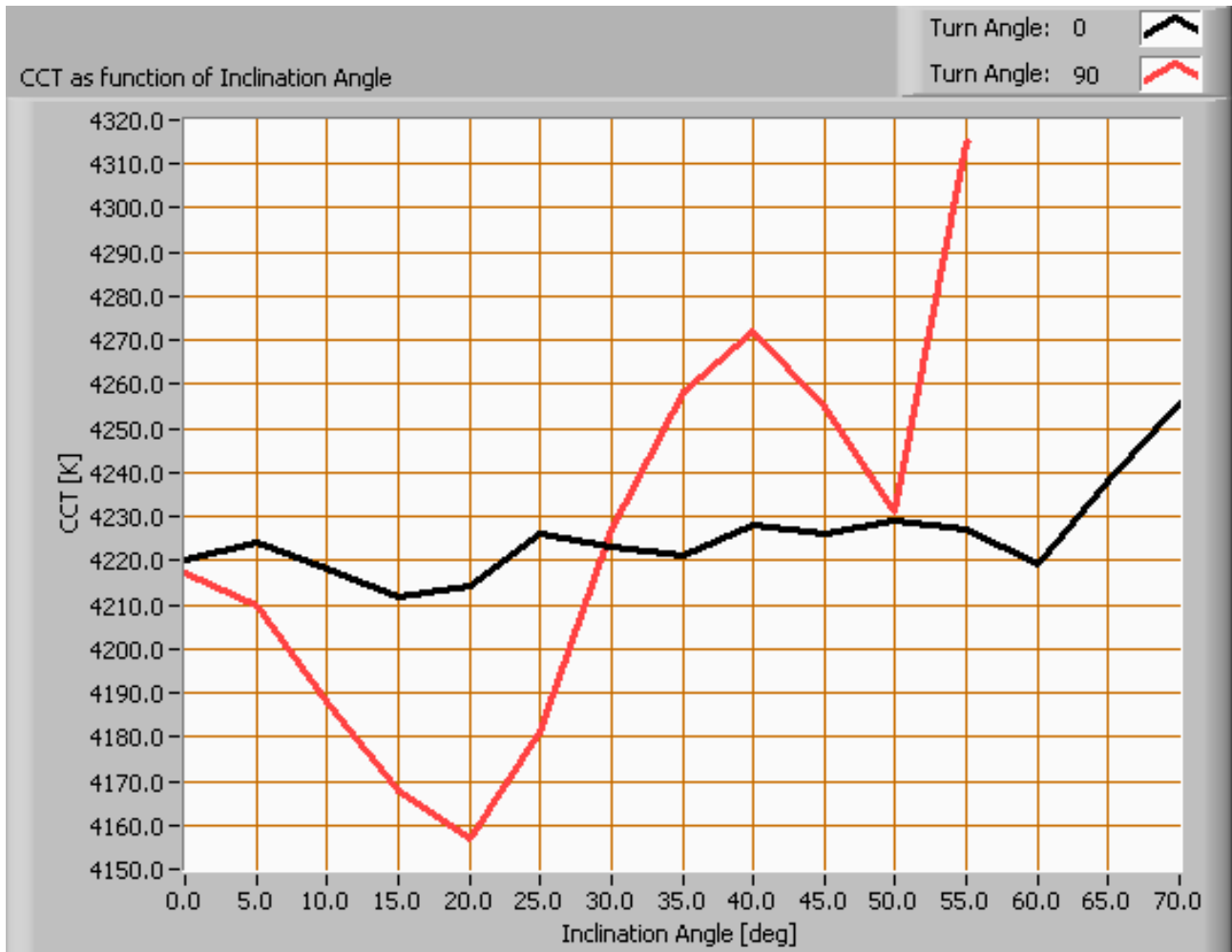


The spectral power distribution of this light bulb, energies on y-axis valid at 1 m distance.

The measured color temperature is about 4225 K which is neutral 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.

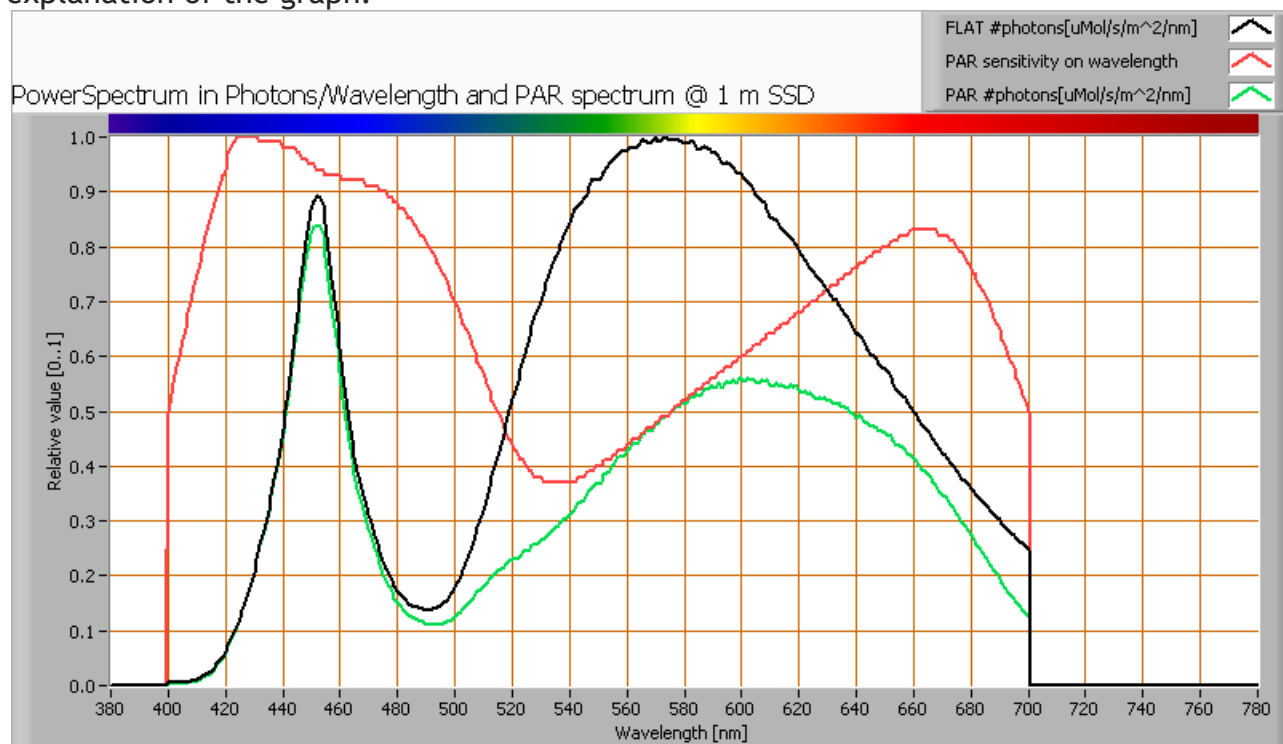
The measurement of CCT is measured for inclination angles up to 55° as beyond that angle the illuminance values are very low (< 5 lux).

The beam angle is maximally 101°, meaning a 50.5° inclination angle. In this area most of the light is present. The variation in correlated color temperature in this area is about 1 %.

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PAR value and PAR spectrum

To make a statement how well the light of this light bulb is for growing plants, the PAR-area needs to be determined. See the OLiNo website how this all is determined and the explanation of the graph.



The photon spectrum, then the sensitivity curve and as result the final PAR spectrum of the light of this light bulb

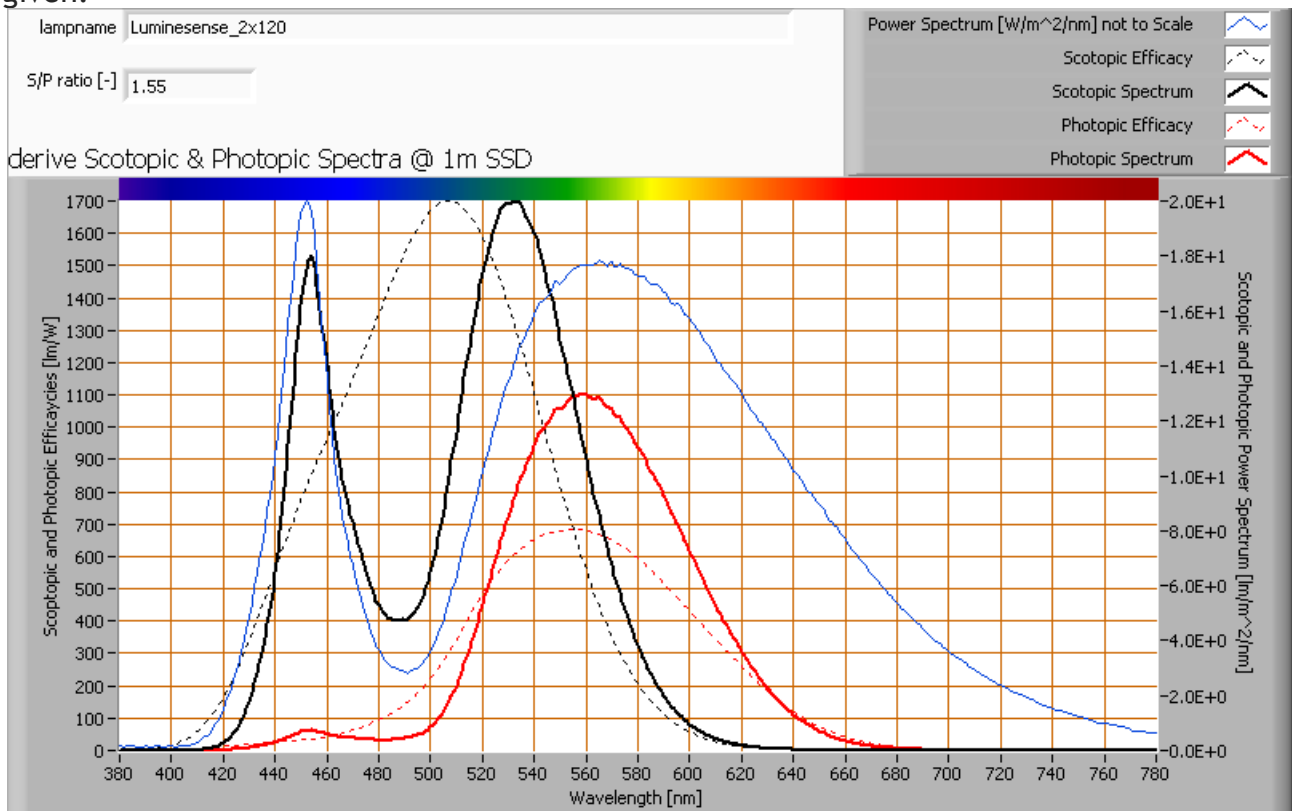
parameter	value	unit
PAR-number	9.6	$\mu\text{Mol/s/m}^2$
PAR-photon current	27.5	$\mu\text{Mol/s}$
PAR-photon efficacy	0.6	$\mu\text{Mol/s/W}$

The PAR efficiency is 64 % (valid for the PAR wave length range of 400 - 700 nm). So maximally 64 % of the total of photons in the light is effectively used by the average plant (since the plant might not take 100 % of the photons at the frequency where its relative sensitivity is 100 %).

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S/P ratio

The S/P ratio and measurement is explained on the OliNo website. Here the results are given.



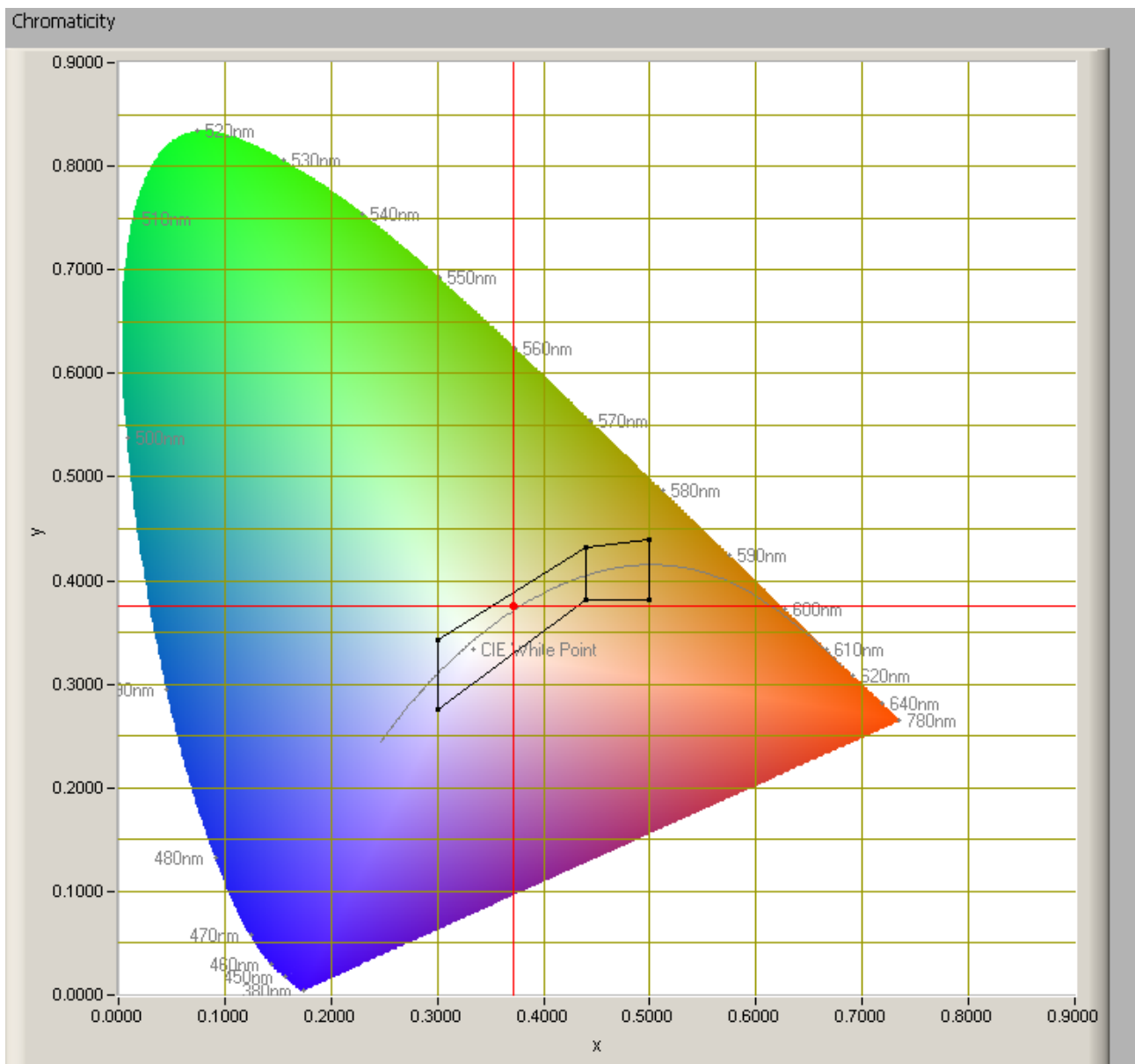
The power spectrum, sensitivity curves and resulting scotopic and photopic spectra (spectra energy content defined at 1 m distance).

The S/P ratio is 1.6.

More info on S/P ratio can be found on the OliNo website.

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Chromaticity diagram



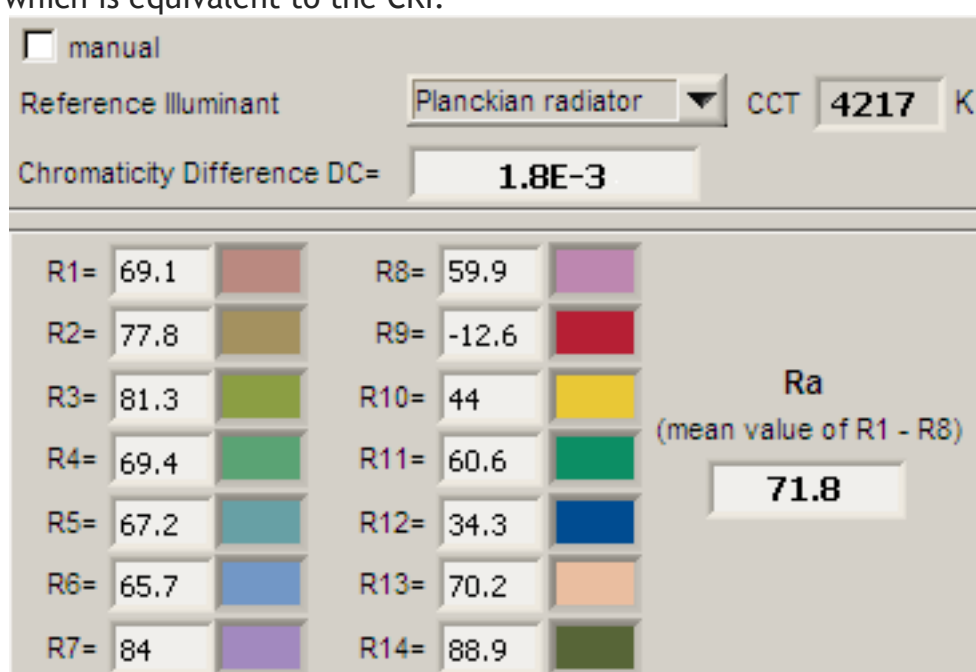
The chromaticity space and the position of the lamp's color coordinates in it.

The light coming from this lamp is inside the area designated with class A. This Class A is an area that is defined for signal lamps, see also the OLiNo website.
Its coordinates are $x=0.3721$ and $y=0.3751$.

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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). Practical information and also some critics about the CRI can be found on the OliNo website. Each color has an index R_x , and the first 8 indexes ($R_1 \dots R_8$) are averaged to compute the R_a which is equivalent to the CRI.



CRI of the light of this lightbulb.

The value of 78 is (a bit) lower than 80 which is considered a minimum value for indoor usage.

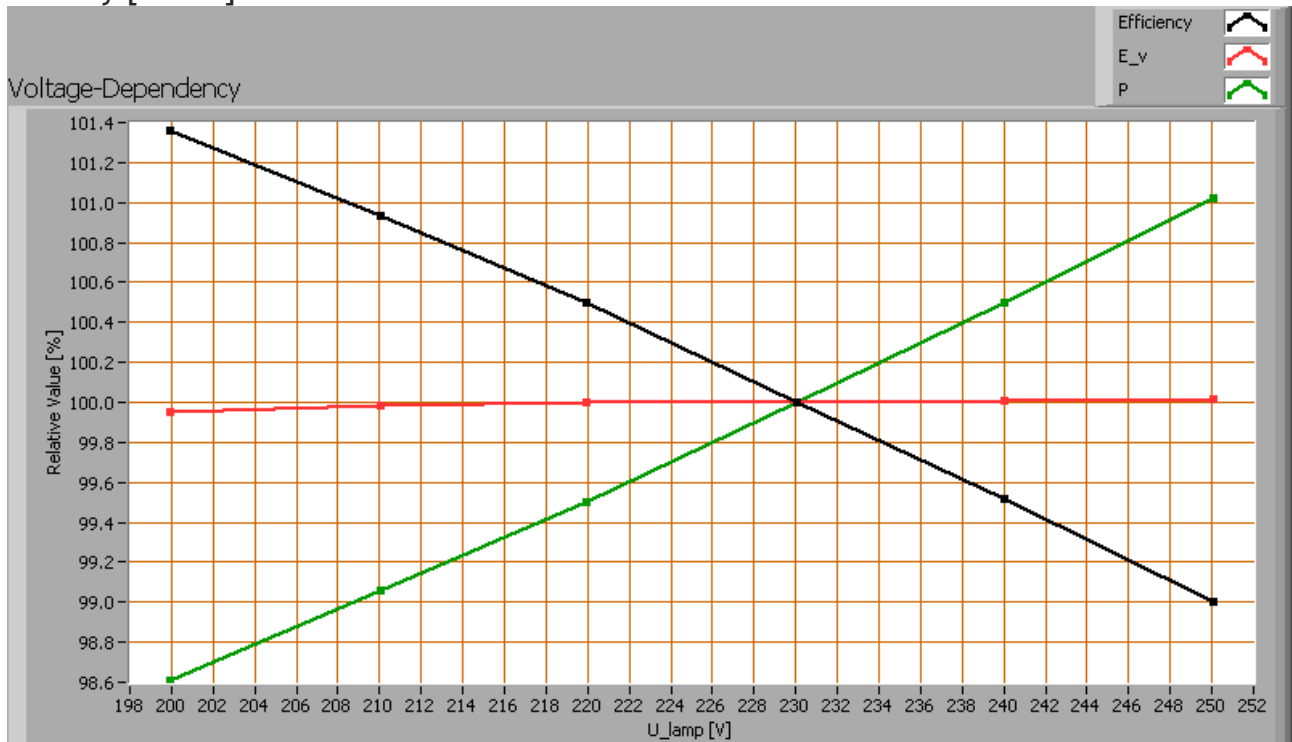
Note: the chromaticity difference is 0.0018 indicates the distance to the Planckian Locus. There is no norm yet that states what the max deviation from white light is allowed to be. A reference with signal lights as a reference is given in the chromaticity diagram.

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

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parameters measured: illuminance E_v [lx], the lamp power P [W] and the luminous efficacy [lm/W].



Lamp voltage dependencies of certain light bulb parameters, where the value at 230 V is taken as 100 %.

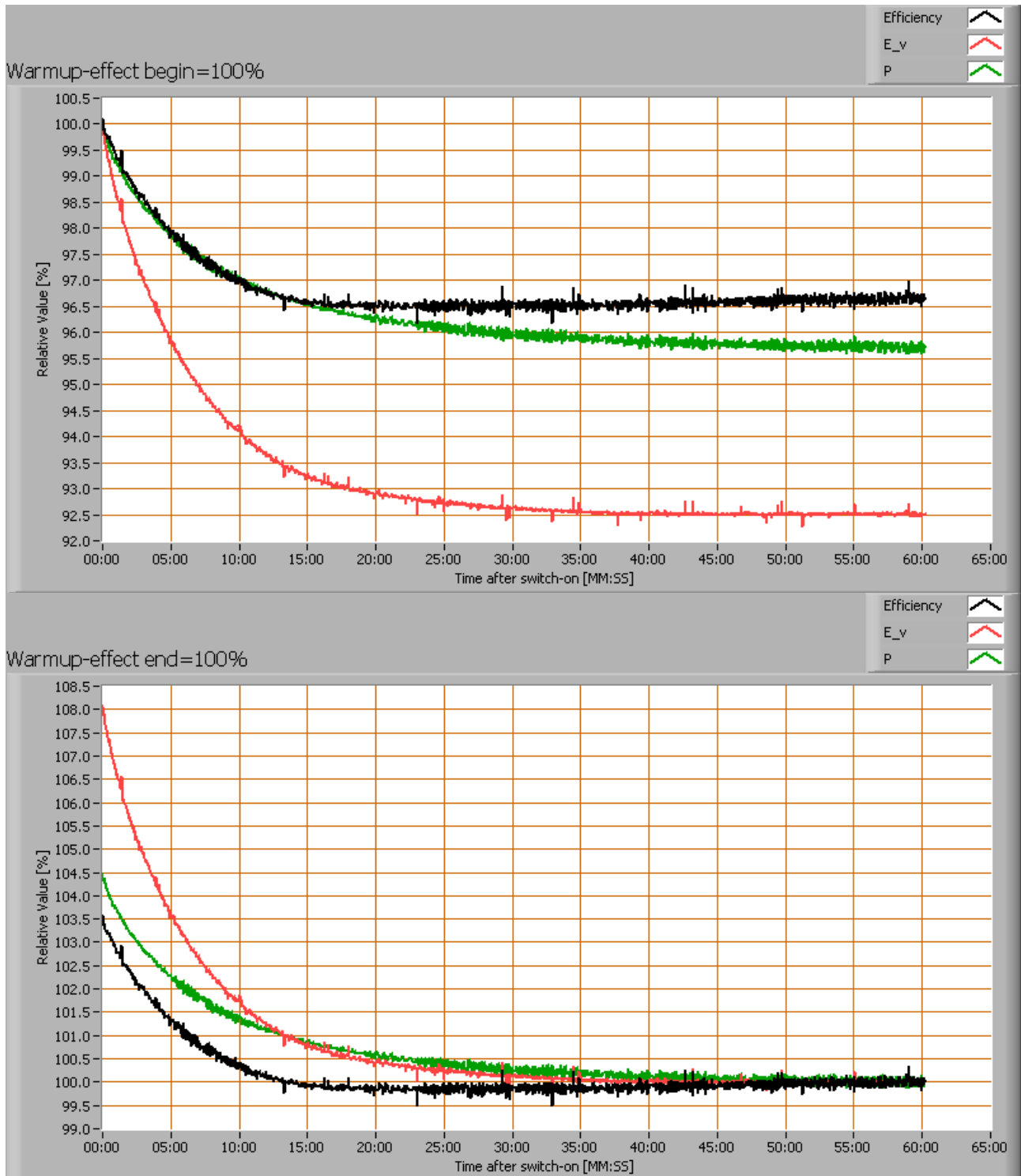
The illuminance and consumed power do not vary significantly when the voltage is varied.

When the voltage at 230 V varies with + and - 5 V, then the illuminance varies < 0.1 %, so when abrupt voltage changes occur this effect is not visible in the illuminance output.

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 lamp power P [W] and the luminous efficacy [lm/W].

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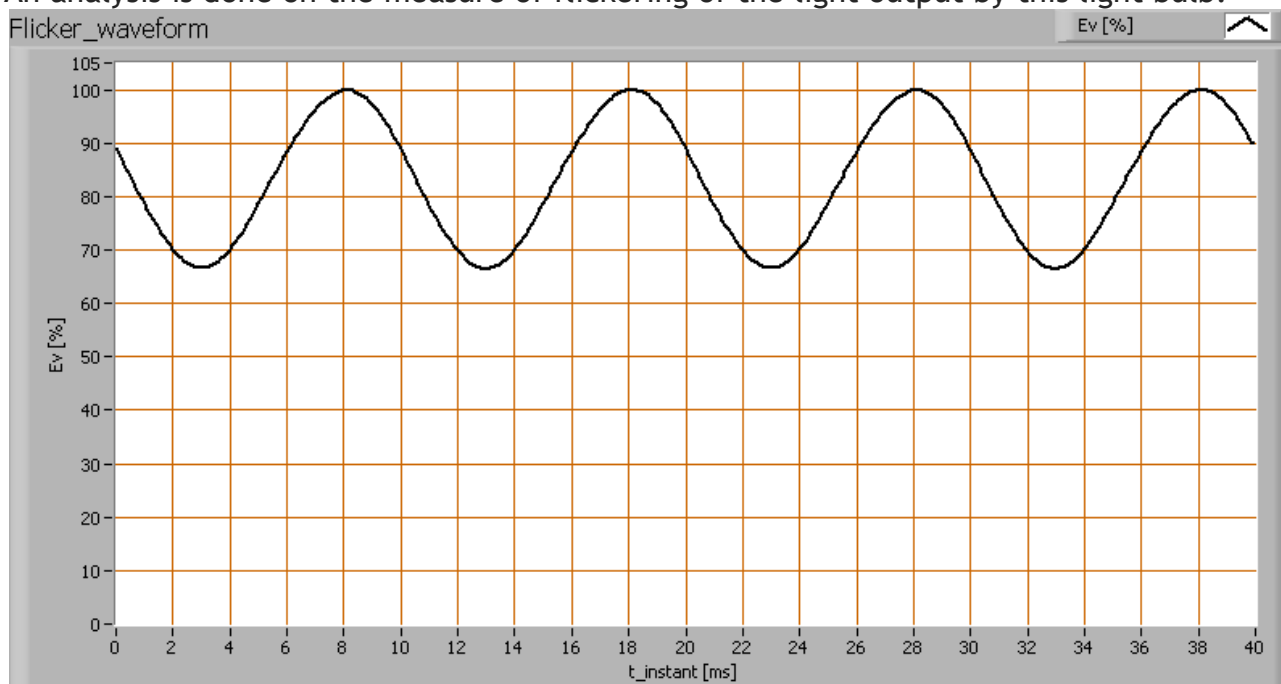
Effect of warming up on different light bulb parameters. At top the 100 % level is put at begin, and at bottom at the end.

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The warm up time is about 20 minutes. During that time the the illuminance decreases with 7 % and the consumed power with 4 %.

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	waarde	eenheid
Flicker frequency	100.1	Hz
Illumination modulation index	20	%

The illumination modulation index is computed as: $(\max_Ev - \min_Ev) / (\max_Ev + \min_Ev)$.

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