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BV AR111 WW new Reflector old/current Heatsink
by
Line Lite International BV

Photo courtesy by www.OliNo.org

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Summary measurement data

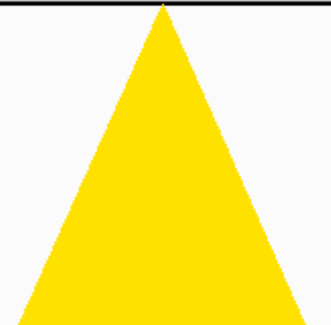| parameter	meas. Result	remark
Color temperature	2906 K	Warm white
Luminous intensity I_v	303 Cd	
Beam angle	41 deg	
Power P	8.5 W	The used power supply drives 350 mA, see for photo at end.
Power Factor	0.61	For every 1 kWh net power consumed, there has been 1.3 kVAhr for reactive power..
Luminous flux	270 lm	
Luminous efficacy	32 lm/W	
CRI_Ra	72	Color Rendering Index.
Coordinates chromaticity diagram	x=0.4440 and y=0.4069	
Fitting	12V	
PAR-value	2.8 $\mu Mol/s/m^2$	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. Valid for roughly the region within the beam angle.
S/P ratio	1.1	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	110 x 73 mm	External dimensions of the light bulb.
D luminous area	88 mm	Dimensions of the luminous area (used in Eulumdat file). This is equal to the diameter of the reflector at the front side.

General remarks		The ambient temperature during the whole set of measurements was 24.5-25.5 deg C. Heatsink temp was measured to be 24 degrees higher than T_ambient. Warm up effect: during the warm up time the illuminance decreased with 9 %. Voltage dependency: the power consumption nor light output depend on the voltage applied. At the end of the report some additional photos.

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Overview table

m.	Ø 50% C0-180	Ø 50% C90-270	C0-180: 41° C90-270: 41°	E (lux)	Luminaire Efficacy
0.25	0.19	0.19		4847	32 (lumens per Watt)
0.5	0.37	0.37		1212	Half-peak diam C_{0-180} 0.75 x diameter(m)
1	0.75	0.75		303	Half-peak diam C_{90-270}
1.5	1.12	1.12		135	0.75 x diameter(m)
3	2.25	2.25		34	Illuminance
4	3	3		19	303 / distance² (lux)
5	3.75	3.75		12	Total Output 270 (lumens)

The illuminance values are measured in the far field (i.e. at least 5 times the distance of the largest illumination dimension) such that the light bulb can be seen as a point source. From this distance the values are calculated to values at the given distances. If the light is not anymore a point source at any given distance, then the real measured values (with an actual lux meter) will be lower than indicated in this table.

Eulumdat light diagram

An interesting graph is the light diagram, indicating the intensity in the C0-C180 and the C90-C270 plane. This light diagram below comes from the program Qlumedit, that extracts these diagrams from an Eulumdat file.
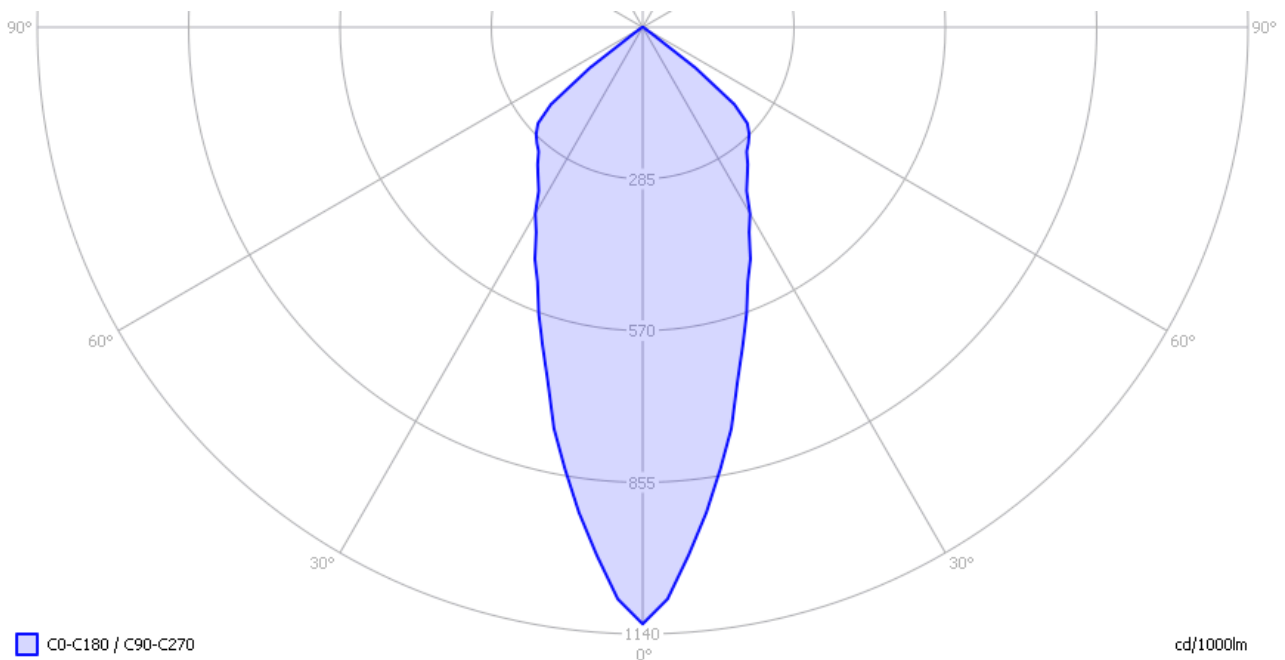
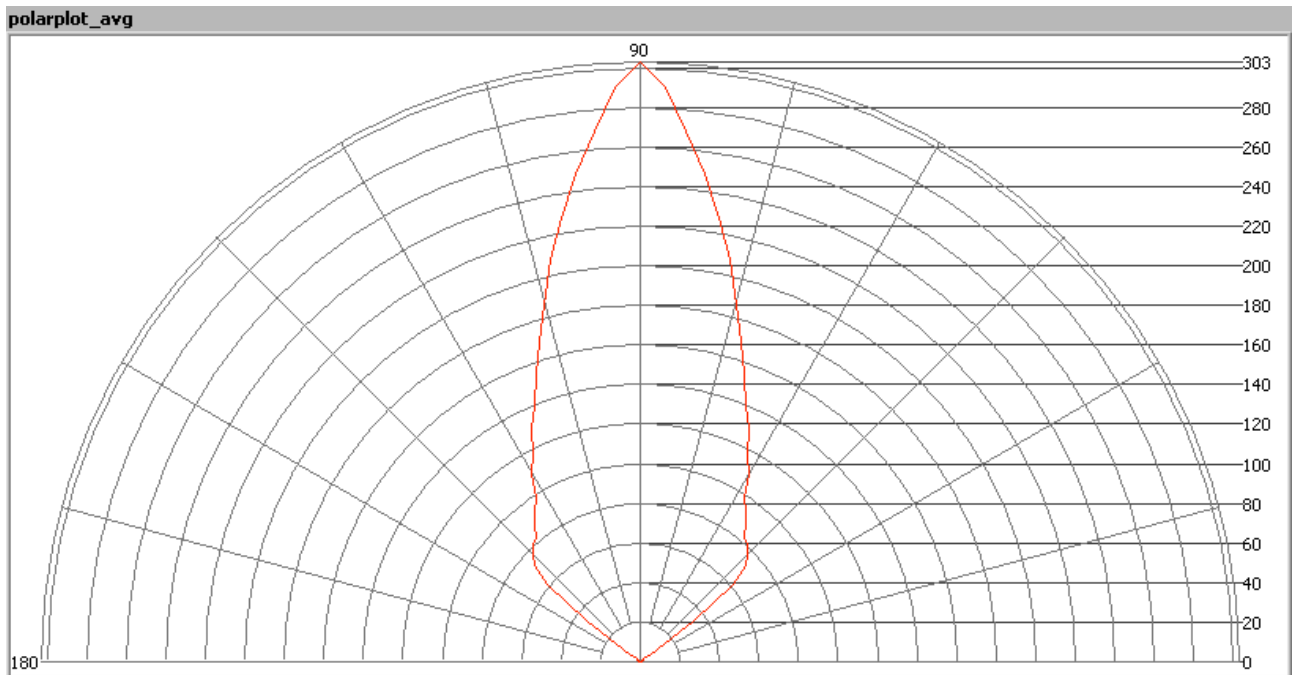*The light diagram giving the radiation pattern.*

It indicates the luminous intensity around the light bulb. This light bulb has the same light diagram for the C0-C180 as for the C90-C270 plane since it has symmetry over 360 degrees.

The unit is Cd/1000lm, meaning the intensity in Cd assuming there would be 1000 lumen in the measured light bulb. This enables comparing different types of light bulbs.

Illuminance Ev at 1 m distance, or luminous intensity Iv

Herewith the plot of the *averaged* luminous intensity Iv 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.
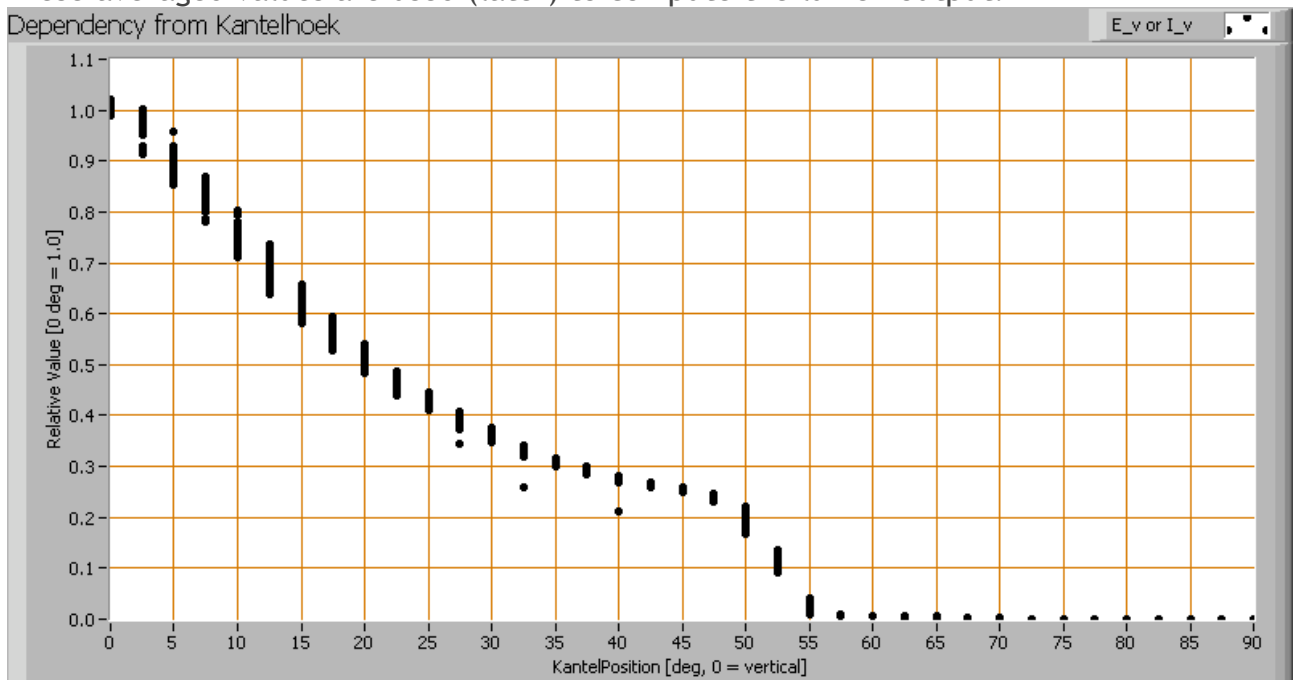
Intensity data of every measured turn angle at each inclination angle.

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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 41 degrees. This is the average value but as the light bulb has a symmetry over 360 degrees, this angle is valid for all turn-angles the light bulb is looked at.

This 41 deg angle is somewhat smaller than the beam angle with the new AR 111 CW (with new heatsink) which had 45 deg beam angle.

Note: the decay of the light after 40 % is slow; the intensity stays relatively long around 30 %. This might mean that a beam projected on a surface is wider than just calculated from the 50 % level.

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 270 lm.

Luminous efficacy

The luminous flux being 270 lm, and the power of the light bulb being 8.5 W, yields a luminous efficacy of 32 lm/W.

A power factor of 0.61 means that for every 1 kWh net power consumed, a reactive component of 1.3 kVAr was needed.

Light bulb voltage	230 VAC
Light bulb current	61 mA
Power P	8.5 W
Apparent power S	14.0 VA
Power factor	0.61

Of this light bulb the voltage across ad the resulting current through it are measured and graphed.
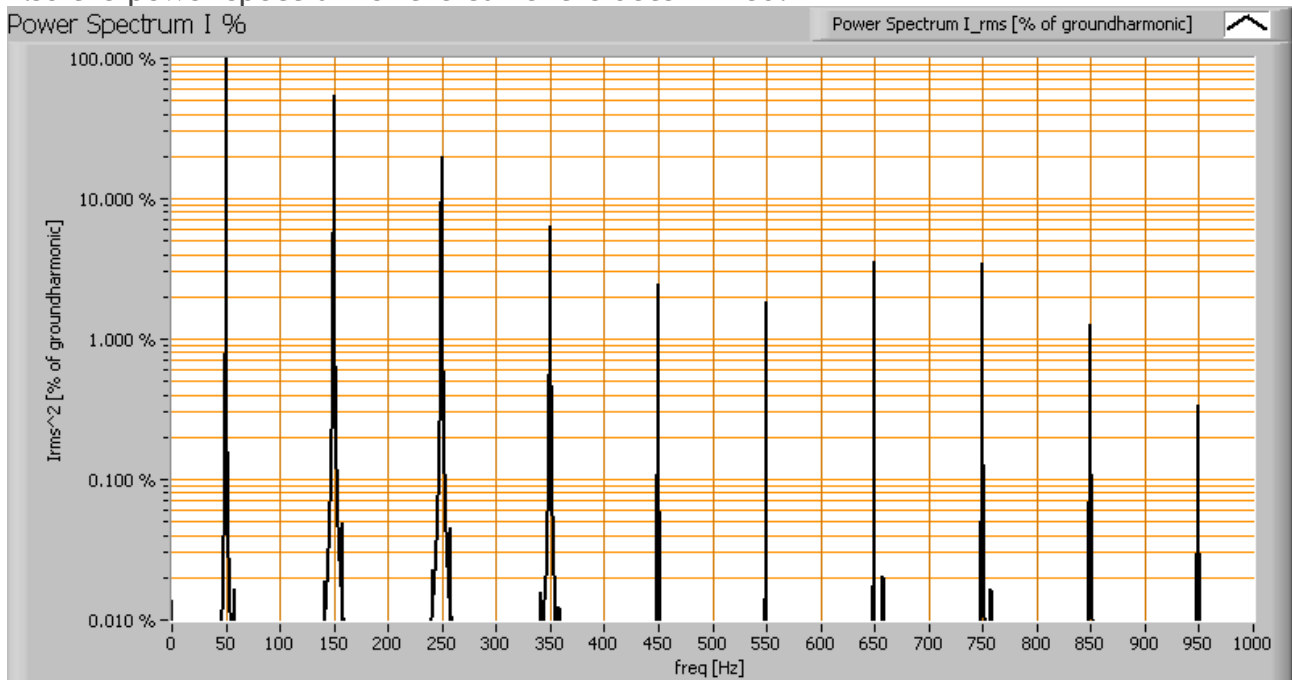
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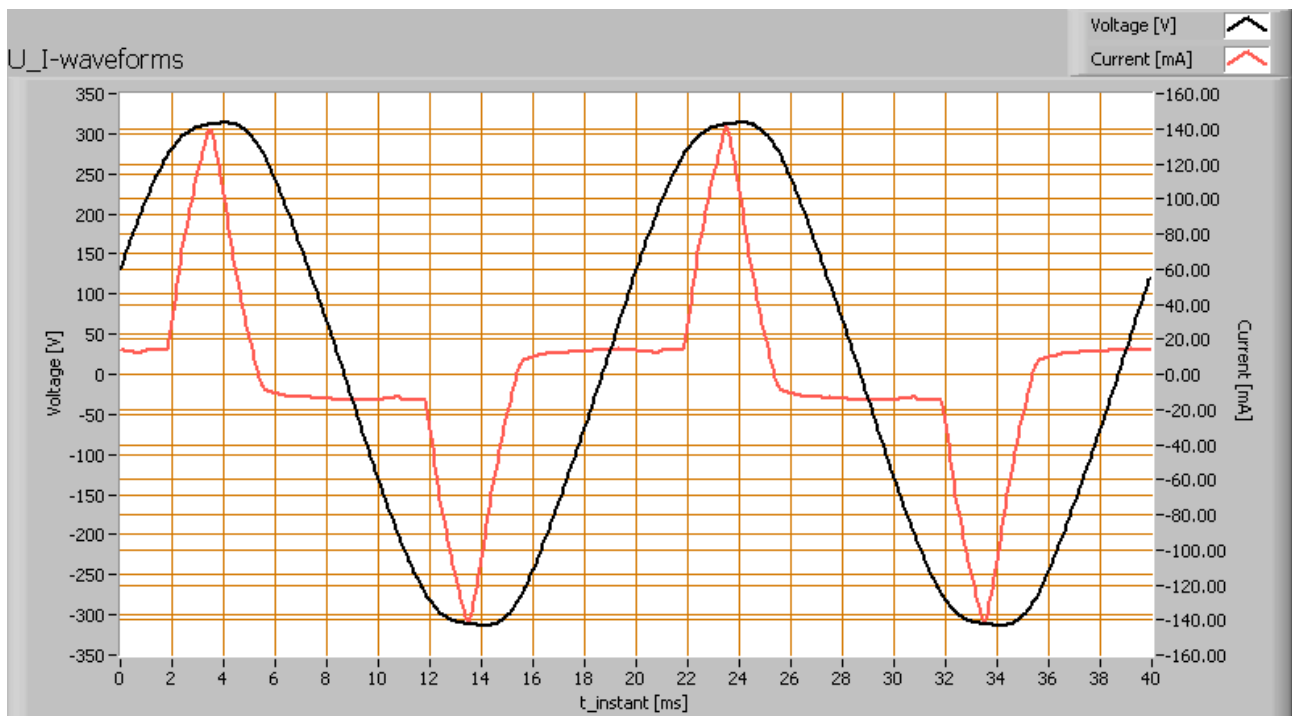
Voltage across and current through the lightbulb

The current is in phase with the voltage but has not a sinusiodal form. Also the symmetry is not the same as the voltage's symmetry. Hence the power factor is low. Also the power spectrum of the current is determined.
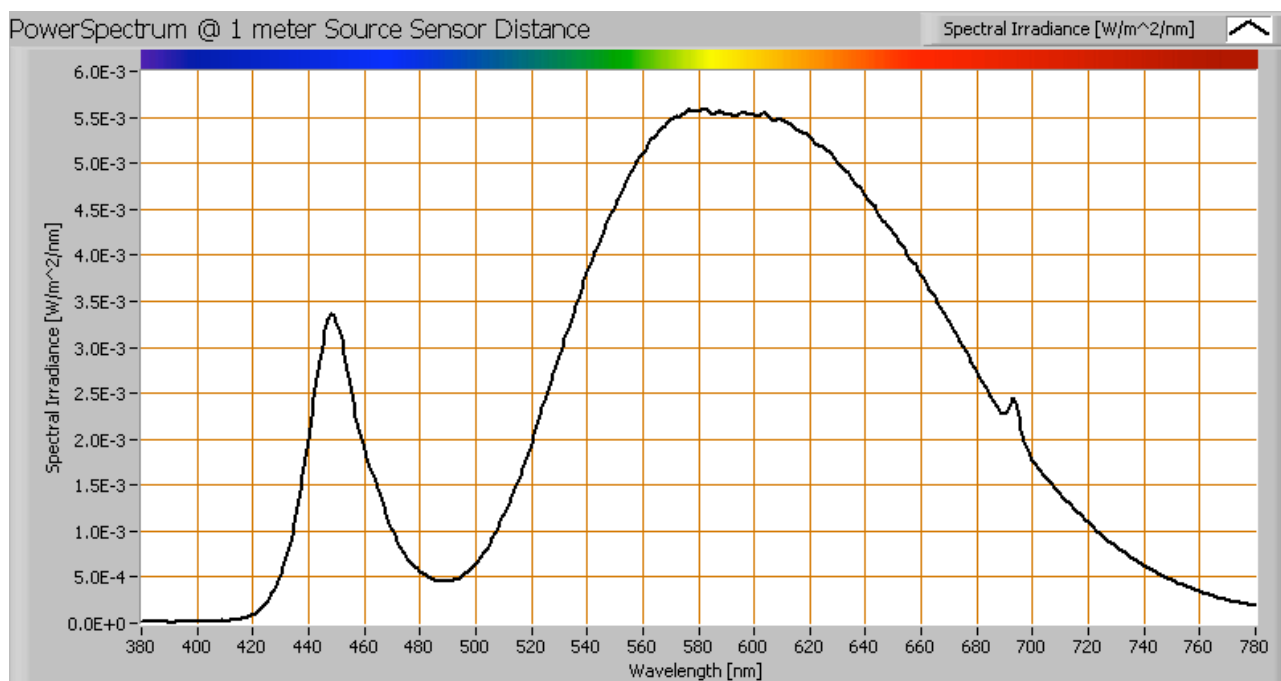
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Current power spectrum in % of the first harmonic (50 Hz).

Due to the peaks in current a lot of higher harmonics are in the current.

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 2900 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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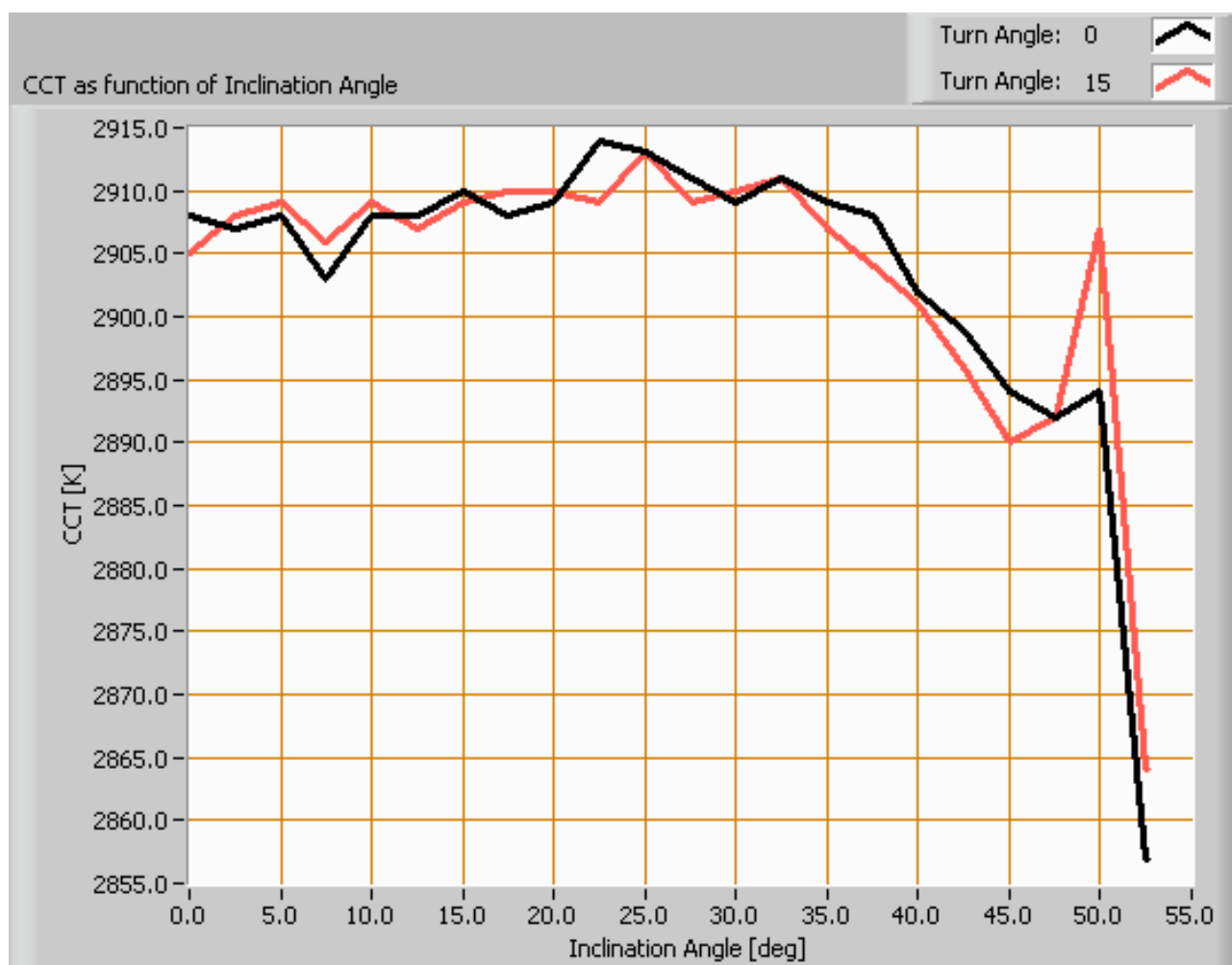
Color temperature as a function of inclination angle.

The beam angle is 41 degrees, meaning at an inclination angle of 20.5 degrees there is 50 % left of the initial illuminance value at 0 degrees. Most of the light energy is within this area. In this area the color temperature remains within 1 % of its value at 0 degrees inclination angle.

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. PAR stands for Photosynthetic Active Radiation which is that radiation that participates actively to photosynthesis and is expressed in $\mu Mol/s/m^2$. Photosynthesis is the essence for growth and flowering of plants, where the blue part of

the light spectrum is responsible for growth and the red part is responsible for flowering and budding (for gemmation). For photosynthesis it is more important to count the number of photons rather than the power in the light.

The power spectrum (power per wave length) of the light of the light bulb is converted into the number of photons (number of photons per wave length) and then these number of photons is weighted against the relative sensitivity of an average plant (which varies in value dependent on the wave length). The relative sensitivity curve in DIN-norm 5031-10:2000 is used for this. The next image shows the result.
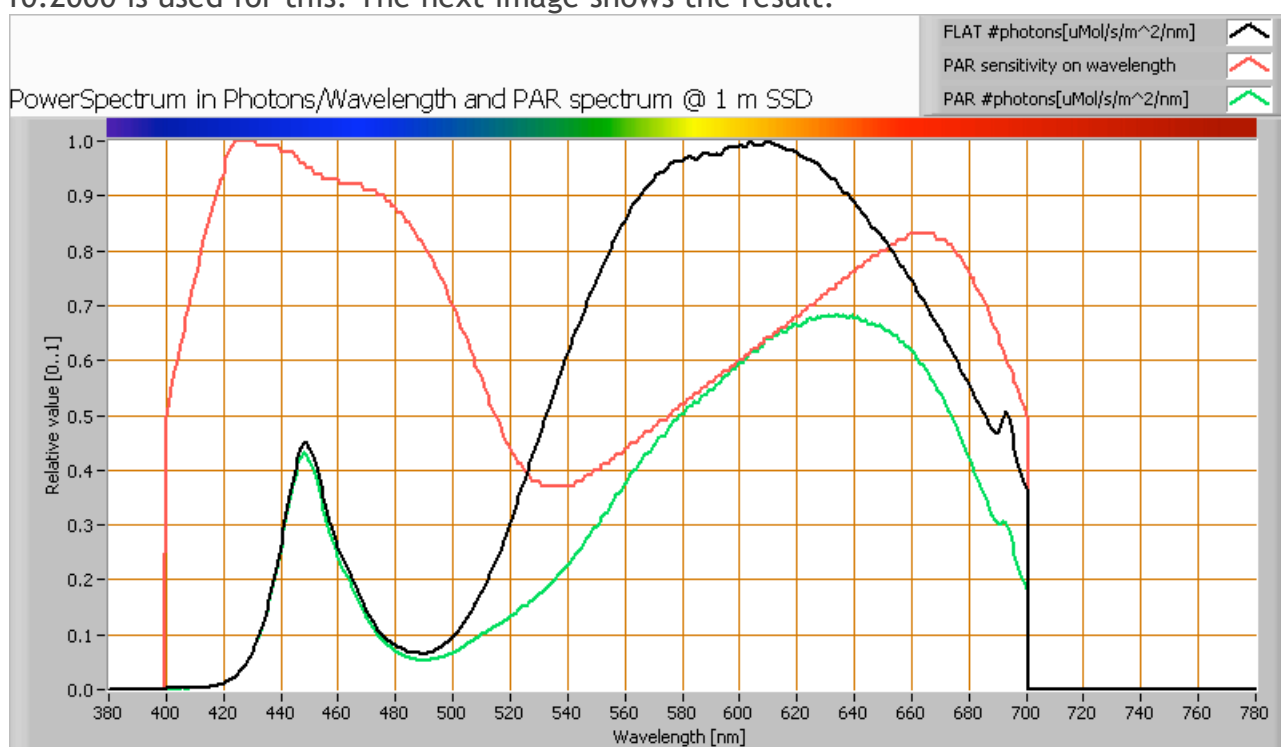
The photon spectrum, then the sensitivity curve and as result the final PAR spectrum of the light of this light bulb

The black curve gives the power spectrum of the light of this light bulb, in number of photons per wave length.

In red the relative sensitivity curve of an average plant (according to DIN norm 5031-10:2000).

Multiplying these two results in a curve showing the number of photos per wave length of the light of this light bulb, the PAR spectrum.

Summing all the photons, gives a PAR number that for this light results in 2.8 µMol/s/m². This value is valid at 1 m distance from the light bulb and for the area within the beam

angle.

Dividing the PAR number by the total number of photons of the light of this light bulb gives a sort of PAR efficiency, which 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 %).

Note: when mentioning this percentage of efficiency, it is important to verify if all wavelengths are present in a sufficient manner. Not that only blue light is available, when the plant is going to be used for flowering where specifically red light is needed.

S/P ratio

The human eye uses rods and cones. The rods work at scotopic light levels (twilight, night) and the rods at high(er) light levels (daytime, but also close to twilight). Each type of receptor has its own sensitivity for light. The rods are 2.7 times more sensitive than cones, and most for light at a blueish-greenish color whereas compared to the cones' sensitivity for green light (555 nm). The S/P ratio gives the maximum difference in sensitivity of the rods at their most sensitive wavelength compared to the cones at their's. The more blueish (cold white) the light, the more the S/P ratio can be.

The light of this light bulb has a certain spectrum leading to an S/P ratio of 1.1. The light of this lightbulb at scotopic light levels is perceived this factor higher than it would be a photopic light levels.
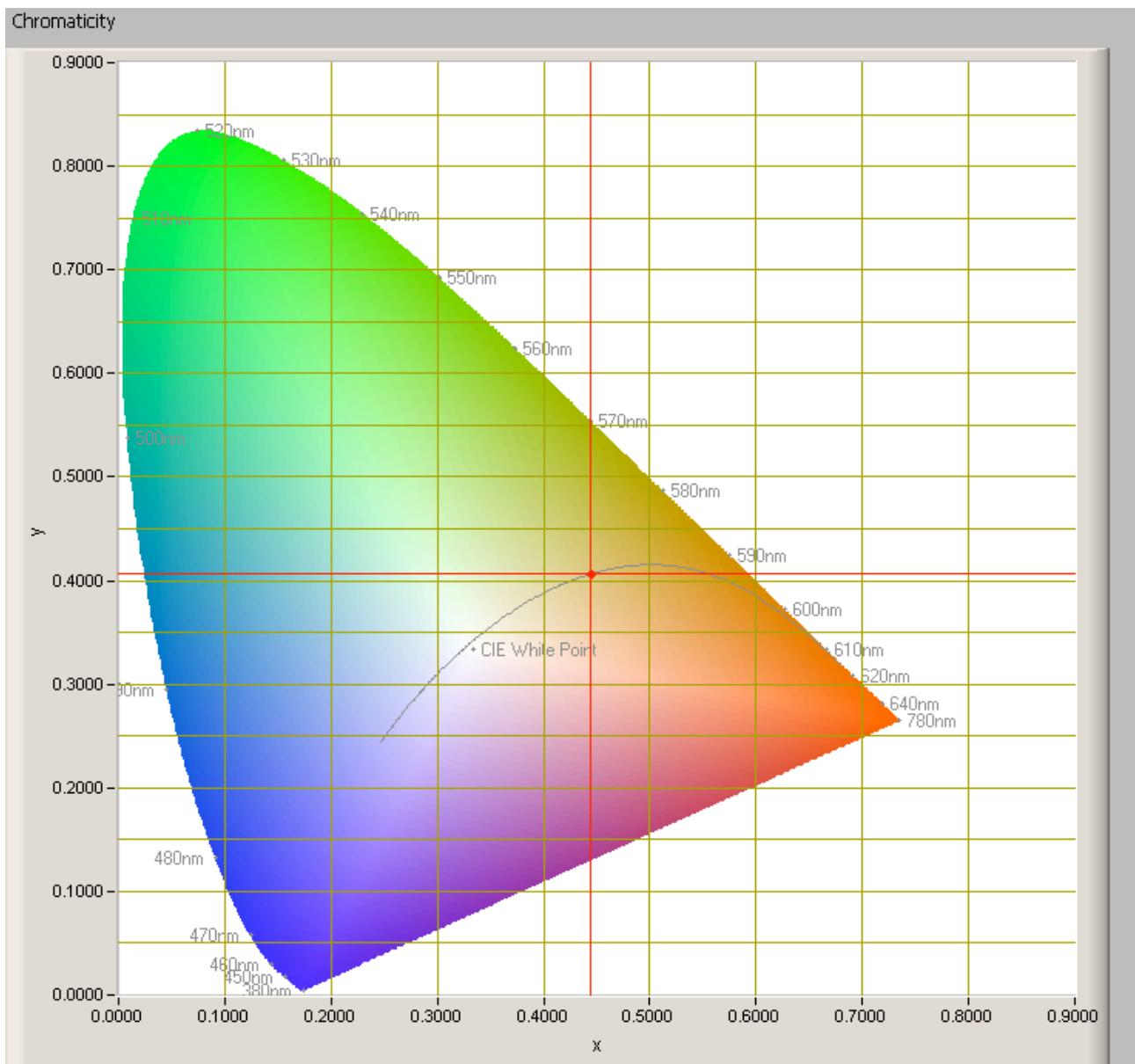
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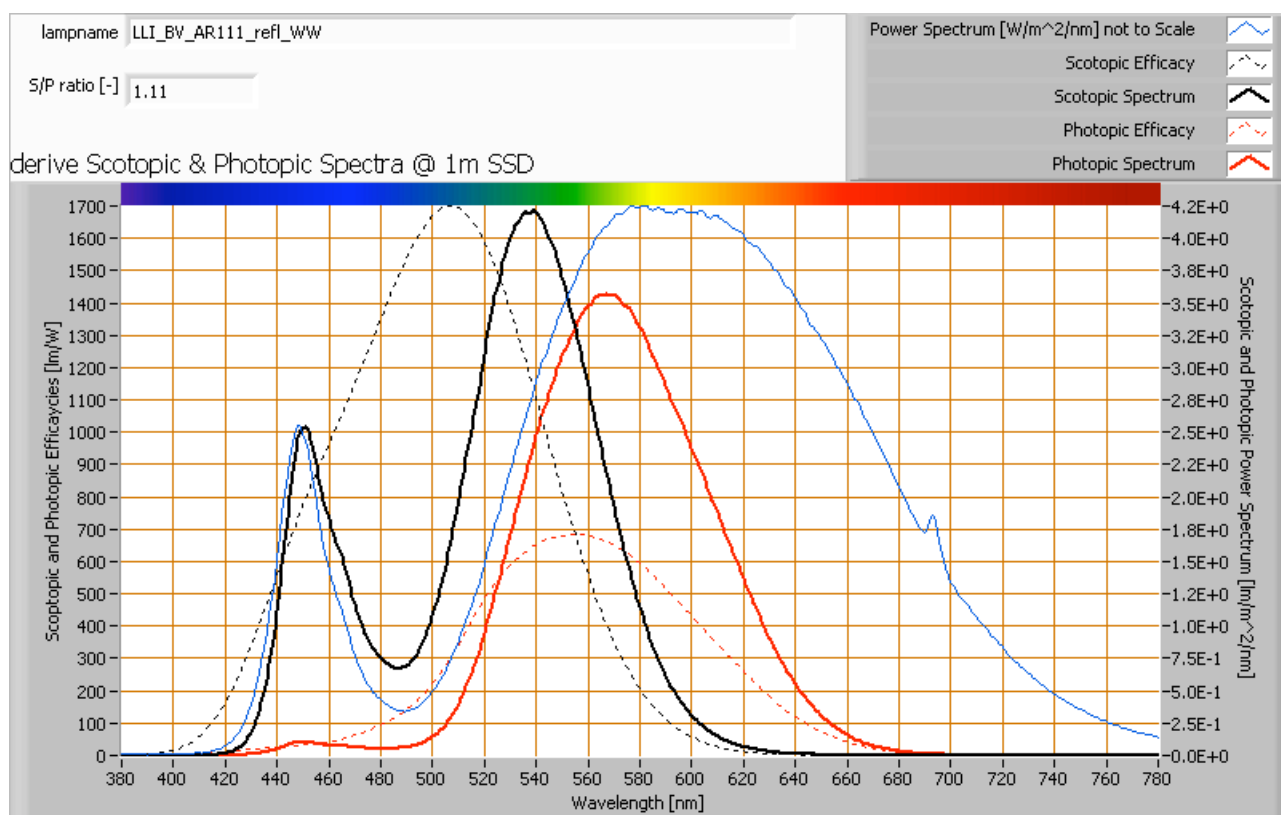
The power spectrum, sensitivity curves and resulting scotopic and photopic spectra (spectra energy content defined at 1 m distance).

There's little of blue in the spectrum and a lot of green, resulting in an S/P ratio which is rather small.

More info on the background of the S/P ratio will come in a separate article.

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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 on top of the Planckian Locus (the black path in the graph).
Its coordinates are x=0.4440 and y=0.4069.

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.

☐ manual		
Reference Illuminant	Planckian radiator ▼	CCT 2906 K
Chromaticity Difference DC=	2.0E-4	

|				
R1= 69.6		R8= 59.1		
R2= 79.8		R9= 2.4		Ra
R3= 85.3		R10= 49.5		(mean value of R1 - R8)
R4= 66.5		R11= 54.6		72
R5= 65.1		R12= 34.3		
R6= 66.3		R13= 70.5		
R7= 84.4		R14= 90.8		

CRI of the light of this lightbulb.

The value of 72 is lower than 80 which is considered a minimum value for indoor usage. Note: the chromaticity difference is 0.0002 and indicates the distance to the Planckian Locus. Its value is lower than 0.0054, which means that the calculated CRI result is meaningful.

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], the (Correlated) Color Temperature [K] and the luminous efficacy [lm/W].

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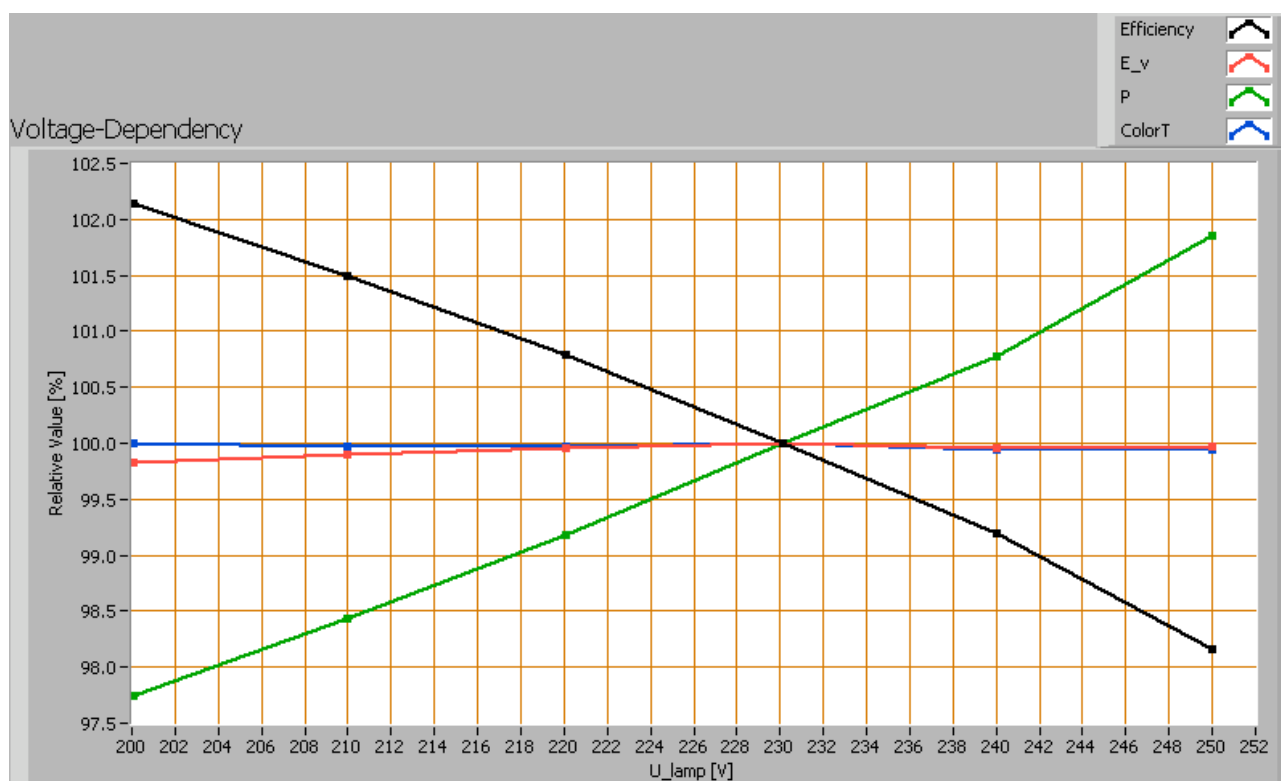
*Lamp voltage dependencies of certain light bulb parameters, where the value at 230 V is taken as 100 %.*

The consumed power varies less than 2.5 % and the illuminane doesn't vary when the voltage varies between 200-250 V. This variation is insignificant.

When the voltage at 250 V varies with + and - 5 V, then the illuminance varies within 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], color temperature CT or correlated color temperature CCT [K], the lamppower P [W] and the luminous efficacy [lm/W].

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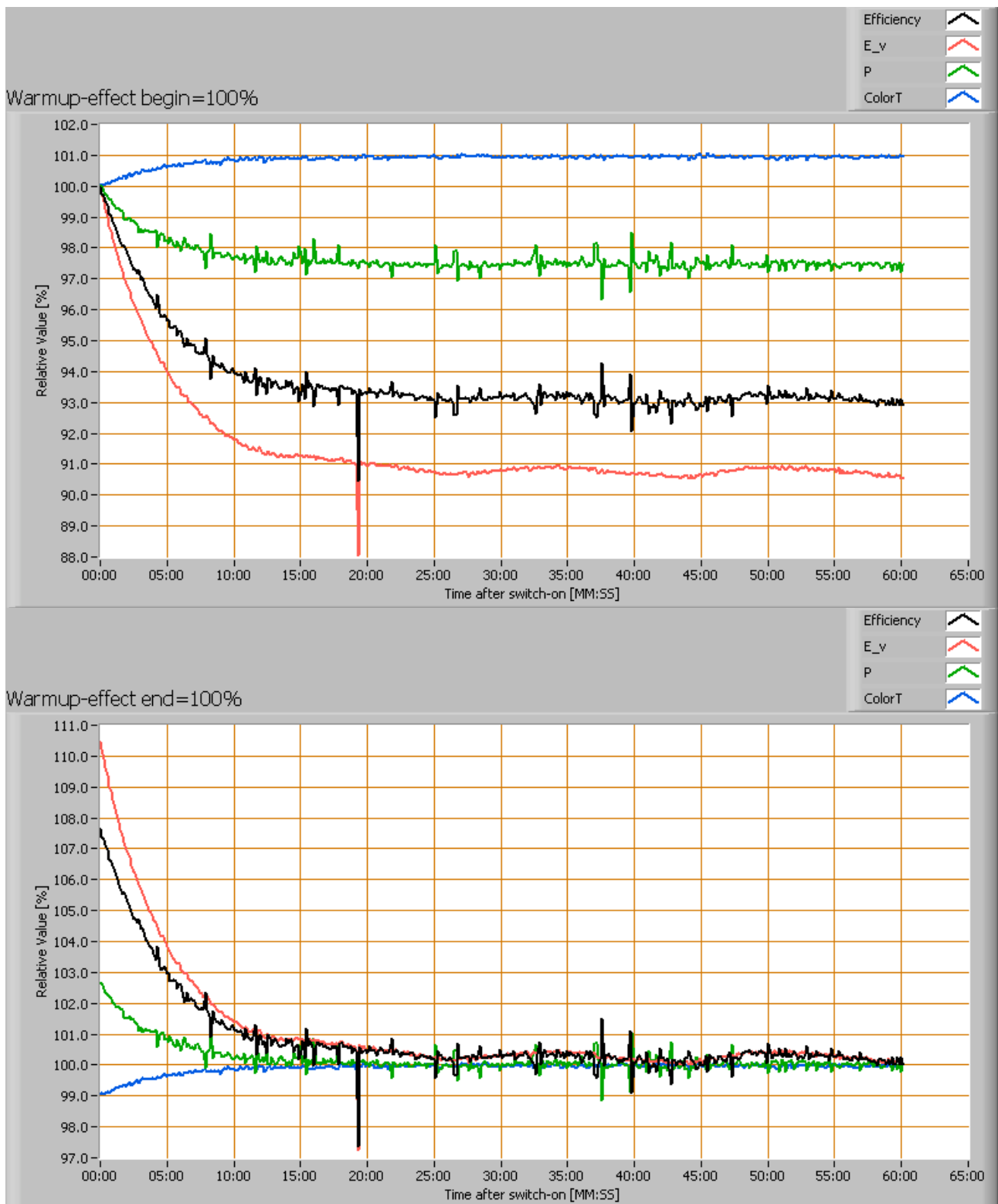
Effect of warming up on different light bulb parameters. At top the 100 % level is put at begin, and at bottom at the end.

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The warm-up time is about 20 minutes, during which the illuminance decreases with 9 %.

Additional photo

Photo courtesy by www.OliNo.org

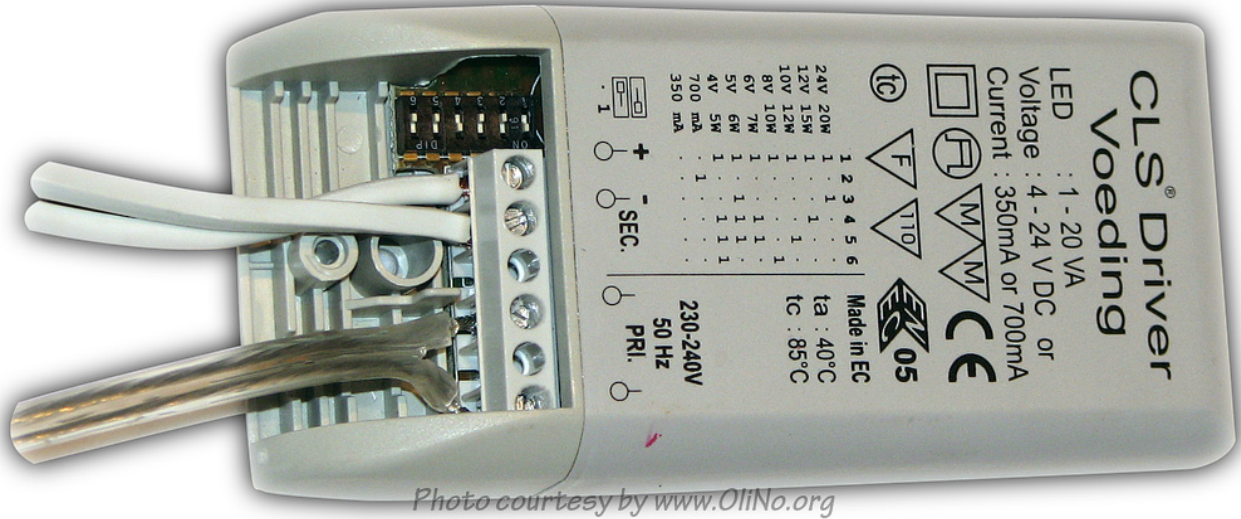*Side view of the light bulb, with the two 12 V clamps at the bottom.*

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Photo courtesy by www.OliNo.org

Left reflector with wide beam, right with small beam. On bottom left the CW and right the WW led-part (with power converter in it).

It is easy to change the reflector, just unscrew and screw.

Used power converter, converting 230 V AC in to 350 mA DC out.

When reading the dip switches, it becomes clear that this power converter operates at max 12 V 15 W at a constant current of 350 mA.

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