

Lamp measurement report – 15 June 2009 for Led Light Europe

Led Light Europe T8-LedTL 22W 1200mm Natural White



Photo courtesy by www.OliNo.org


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Summary measurement data

parameter	meas. result	remark
Color temperature	6878 K	Cold white.
Luminous intensity I_v	255 Cd	
Beam angle	148 deg	
Power P	21 W	
Power Factor	0.96	For every 1 kWh net power consumed, there has been 0.3 kVAhr for reactive power.
Luminous flux	1155 lm	
Luminous efficacy	54 lm/W	
CRI_Ra	81	Color Rendering Index.
Coordinates chromaticity diagram	x=0.3094 and y=0.3104	
Fitting	FL-tube	ATTENTION: this tube must not be directly connected to the grid voltage but use the delivered constant current source.
PAR-value	2.61 $\mu\text{Mol/s/}$ m^2	The number of photons seen by an average plant when it is lit by the light of this light bulb. Value is valid at 1 m distance from the light bulb.
D x L external dimensions	29 x 1200 mm	External dimensions of the light bulb. This excludes the pins.
W x L luminous area	22 x 1159 mm	Dimensions of the luminous area (used in an Eulumdat file). It is the area of the surface on which the leds are mounted.
General remarks		<p>The ambient temperature during the whole set of measurements was 30-30.5 deg C.</p> <p>Warm up effect: during the warm up time the illuminance decreases with 5 % and the consumed power with 4 %.</p> <p>Voltage dependency: the power consumption and illumination are not significantly dependent from the used voltage.</p>

Lamp measurement report – 15 June 2009 for Led Light Europe

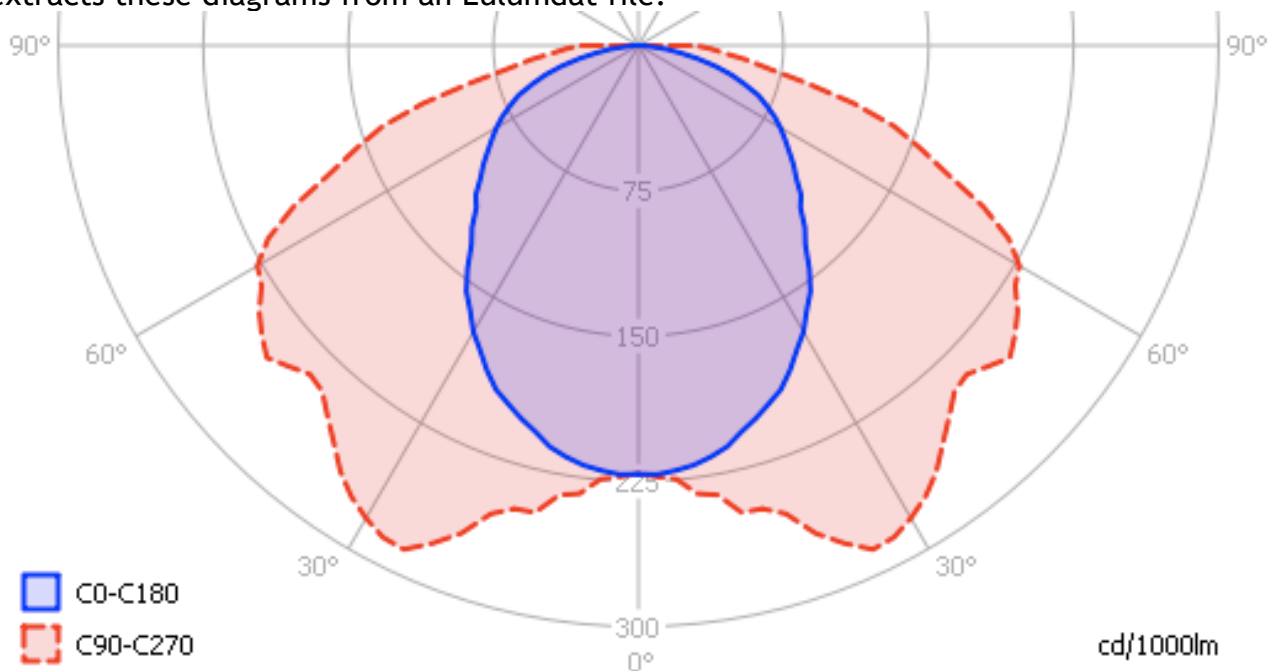
Overview table

m.	∅ 50%	148°	E (lux)	Efficacy
0.25	1.76		4081	54 (lumens per Watt)
0.5	3.52		1020	Half Peak Diameter
1	7.04		255	7.04 × diameter(m)
1.5	10.56		113	Illuminance
3	21.12		28	255 / distance ² (lux)
				Total Output
				1155 (lumens)

Note that the values at 1 m distance are measured and the values at other distances are computed from this value.

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.

Lamp measurement report – 15 June 2009 for Led Light Europe

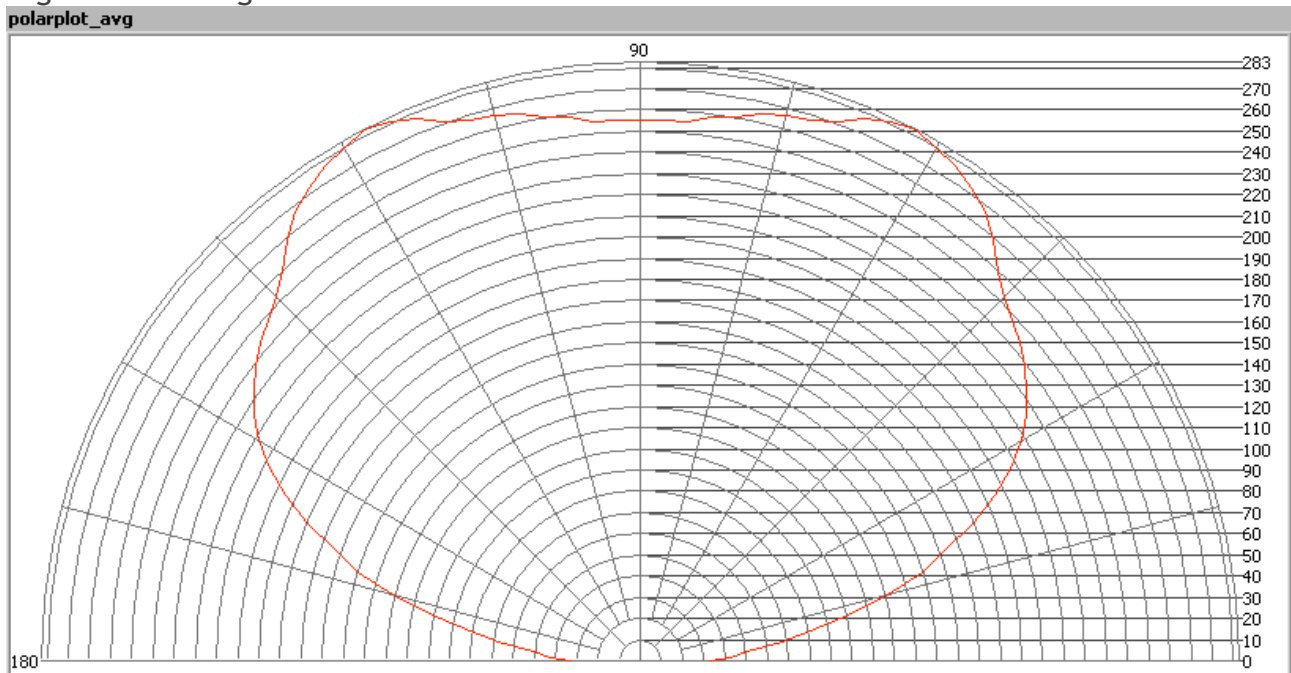
It indicates the luminous intensity around the light bulb. The C0-C180 plane is along the length of the tube light and the C90-C270 perpendicular to that.

It becomes clear that in the C0-C180 direction (the length direction) the light bundle is much smaller than in the C90-C270 direction. The wide beam in this C90-C270 direction results in a lot of light over a wide area underneath this light bulb.

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 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.

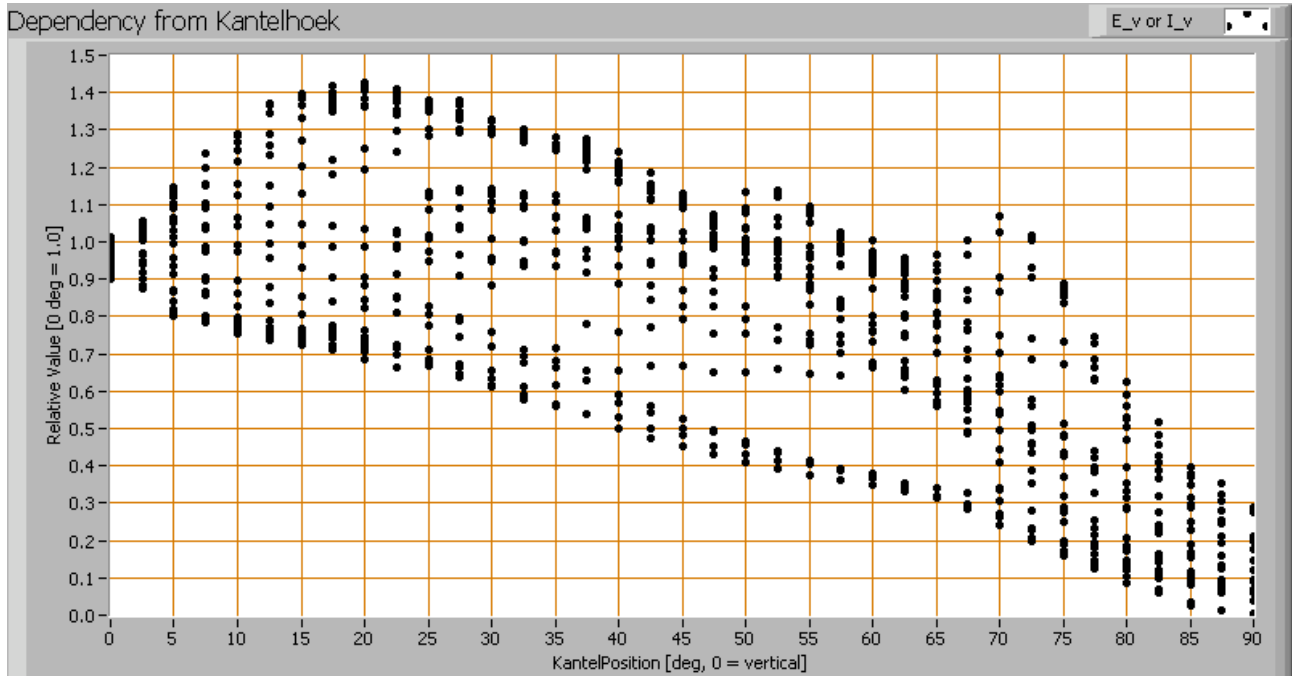


The radiation pattern of the light bulb.

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.

Lamp measurement report – 15 June 2009 for Led Light Europe



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 are little 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 148 degrees. This is the average value which is not valid for all C-planes. In the light diagram at the top, it can be seen that this average value lies close to the value of the C90-C270 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 1155 lm.

Lamp measurement report – 15 June 2009 for Led Light Europe

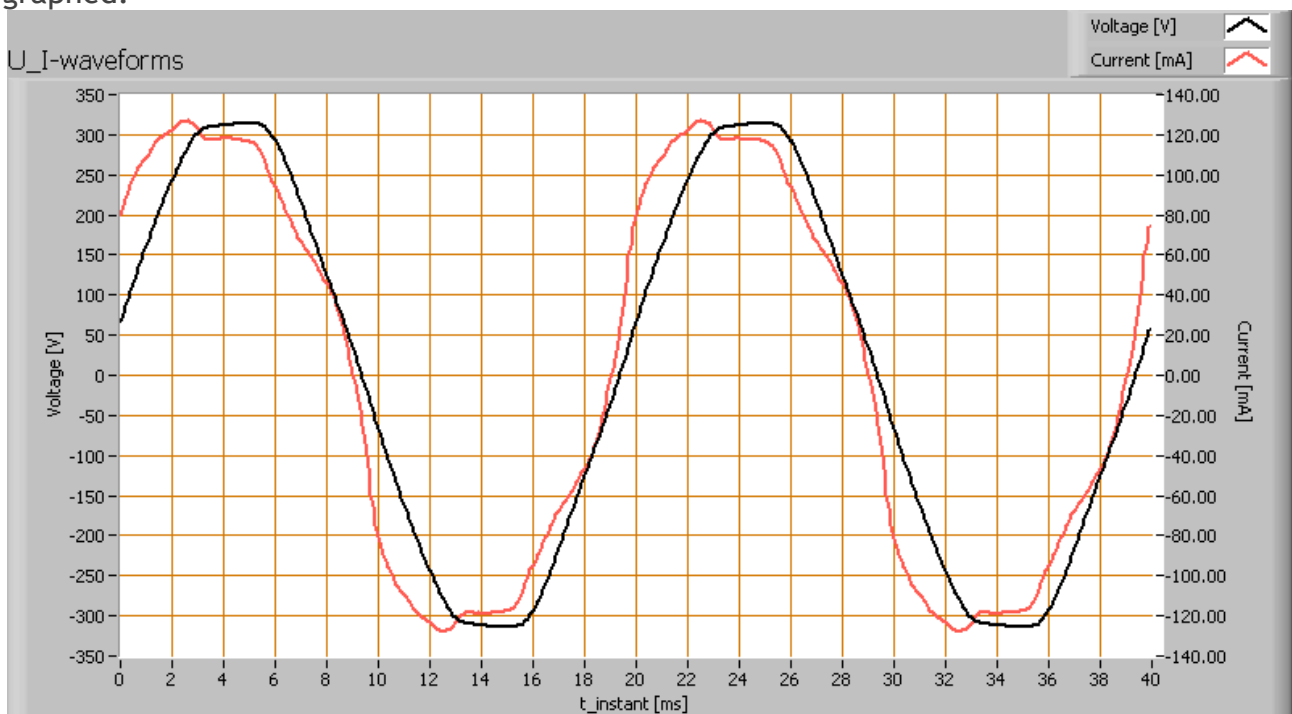
Luminous efficacy

The luminous flux being 1155 lm, and the power of the lightbulb being 21 W, yields a luminous efficacy of 54 lm/W.

A power factor of 0.96 means that for every 1 kWh net power consumed, a reactive component of 0.3 kVAR was needed.

Light bulb voltage	230 VAC
Light bulb current	96 mA
Power P	21 W
Apparent power S	22 VA
Power factor	0.96

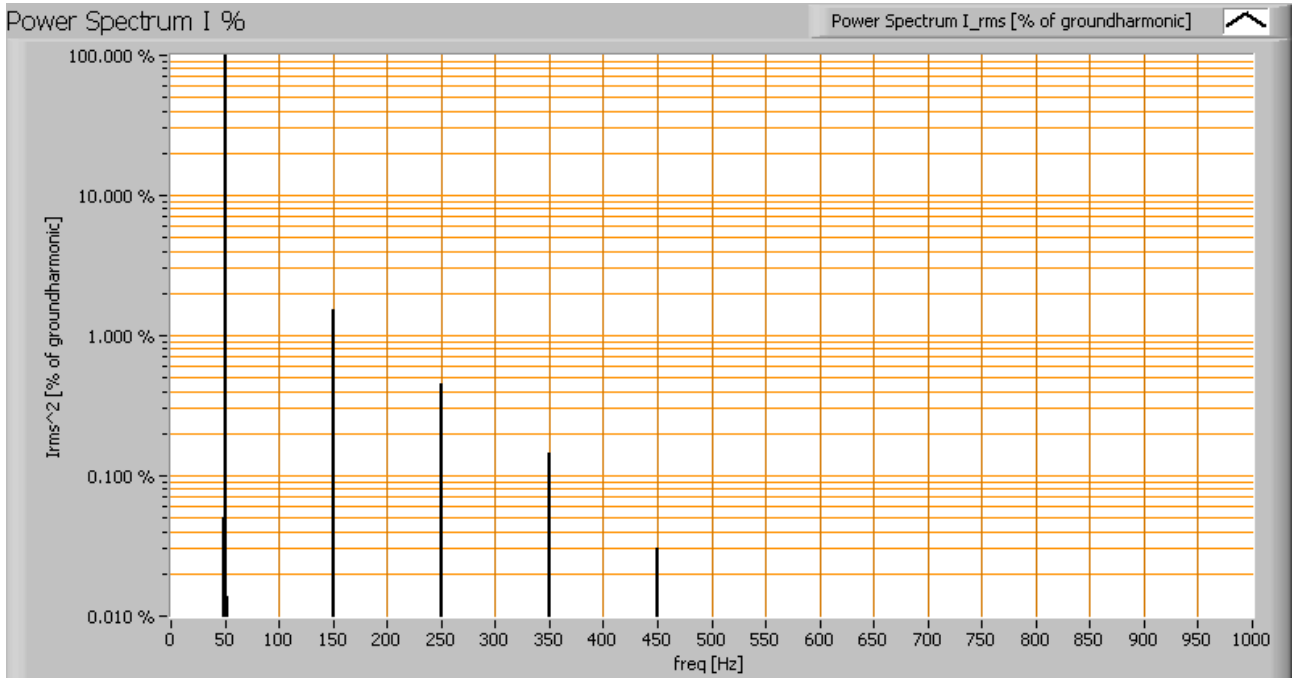
Of this light bulb the voltage across and the resulting current through it are measured and graphed.



Voltage across and current through the lightbulb

The current driver really does its best to take a current from the grid that is in phase with the grid voltage and has a nice sine form. The result is a power factor close to 1. Also the power spectrum of the current is determined.

Lamp measurement report – 15 June 2009 for Led Light Europe

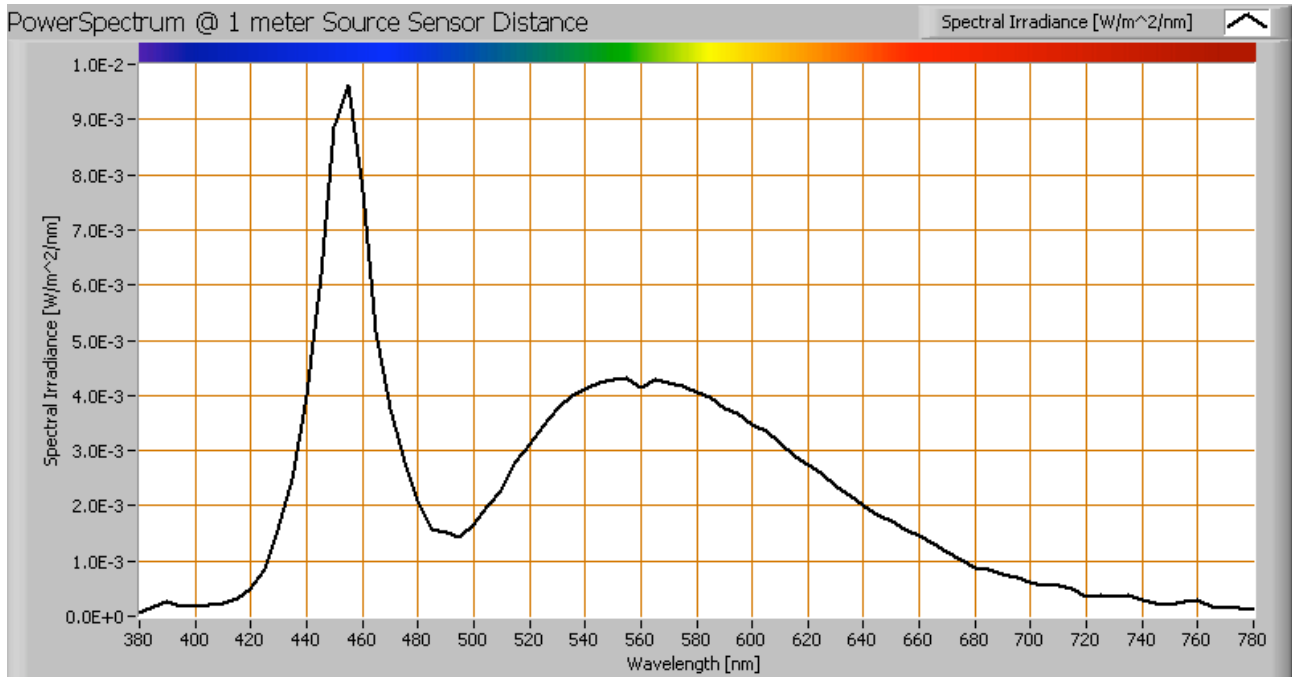


Current power spectrum in % of the first harmonic (50 Hz).

Very few higher harmonics.

Lamp measurement report – 15 June 2009 for Led Light Europe

Color temperature and Spectral power distribution

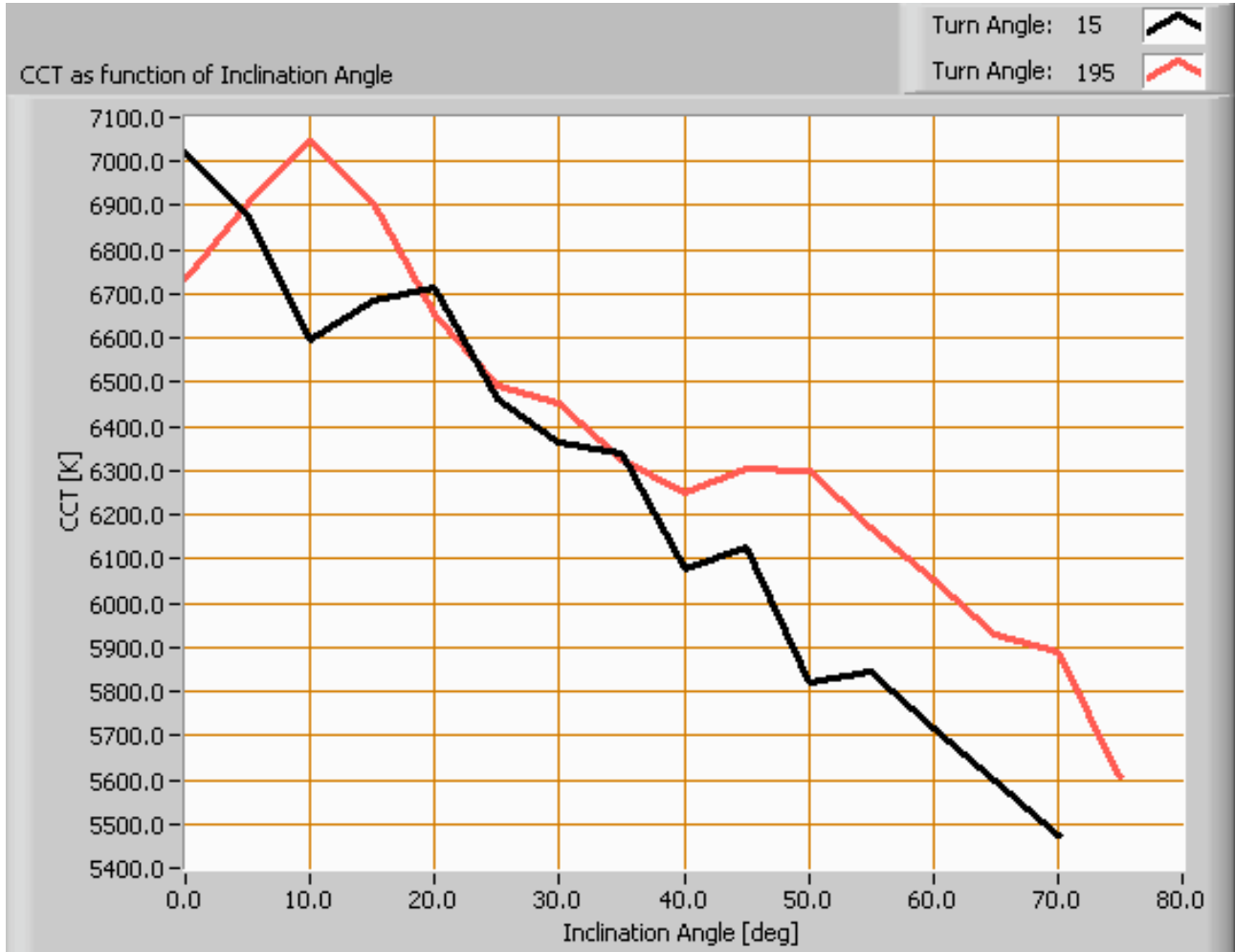


The spectral power distribution of this light bulb. Spectral values are valid at 1 m distance from the light bulb.

The measured color temperature is about 6875 K which is cold white.

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

Lamp measurement report – 15 June 2009 for Led Light Europe



Color temperature as a function of inclination angle.

The color temperature is given for inclination angles up to 70 degrees; at higher inclination angles there is little illumination left.

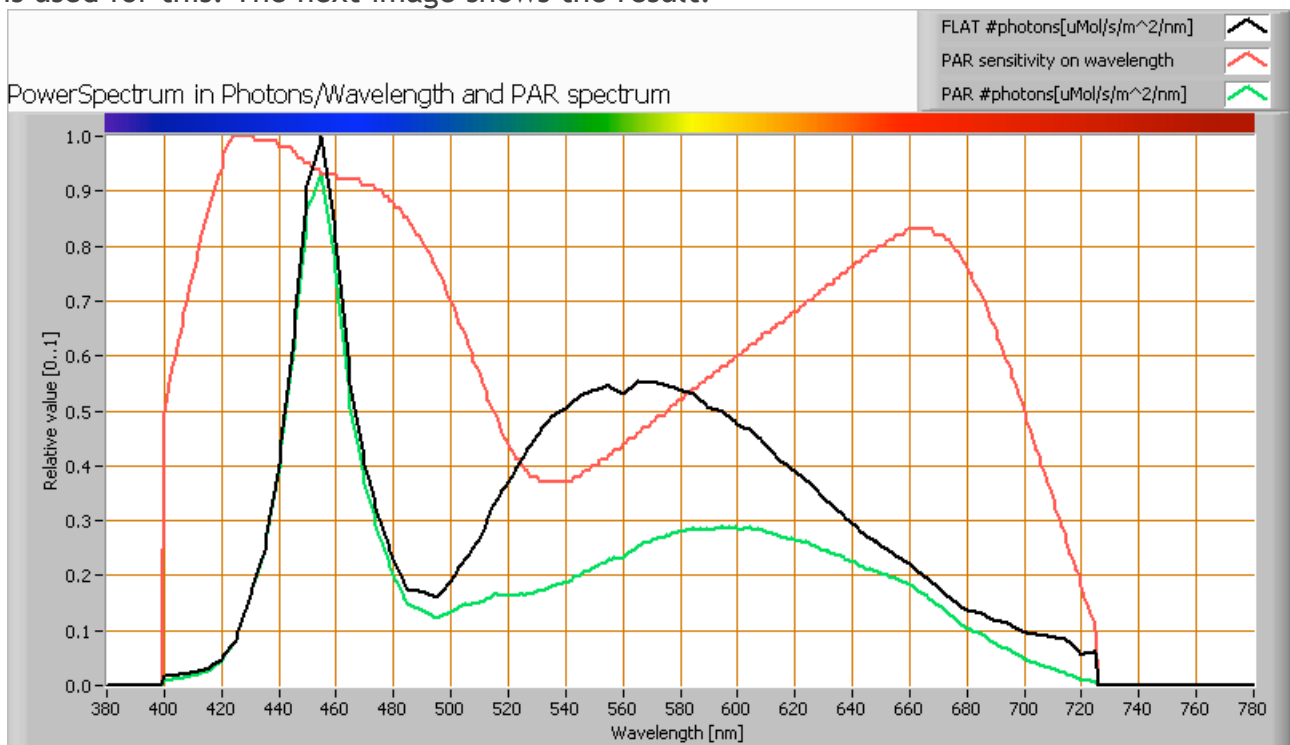
The value slowly decreases. At 70 degrees inclination angle it is at 81 % of its initial value.

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. It is more important then to

Lamp measurement report – 15 June 2009 for Led Light Europe

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 powerspectrum 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).

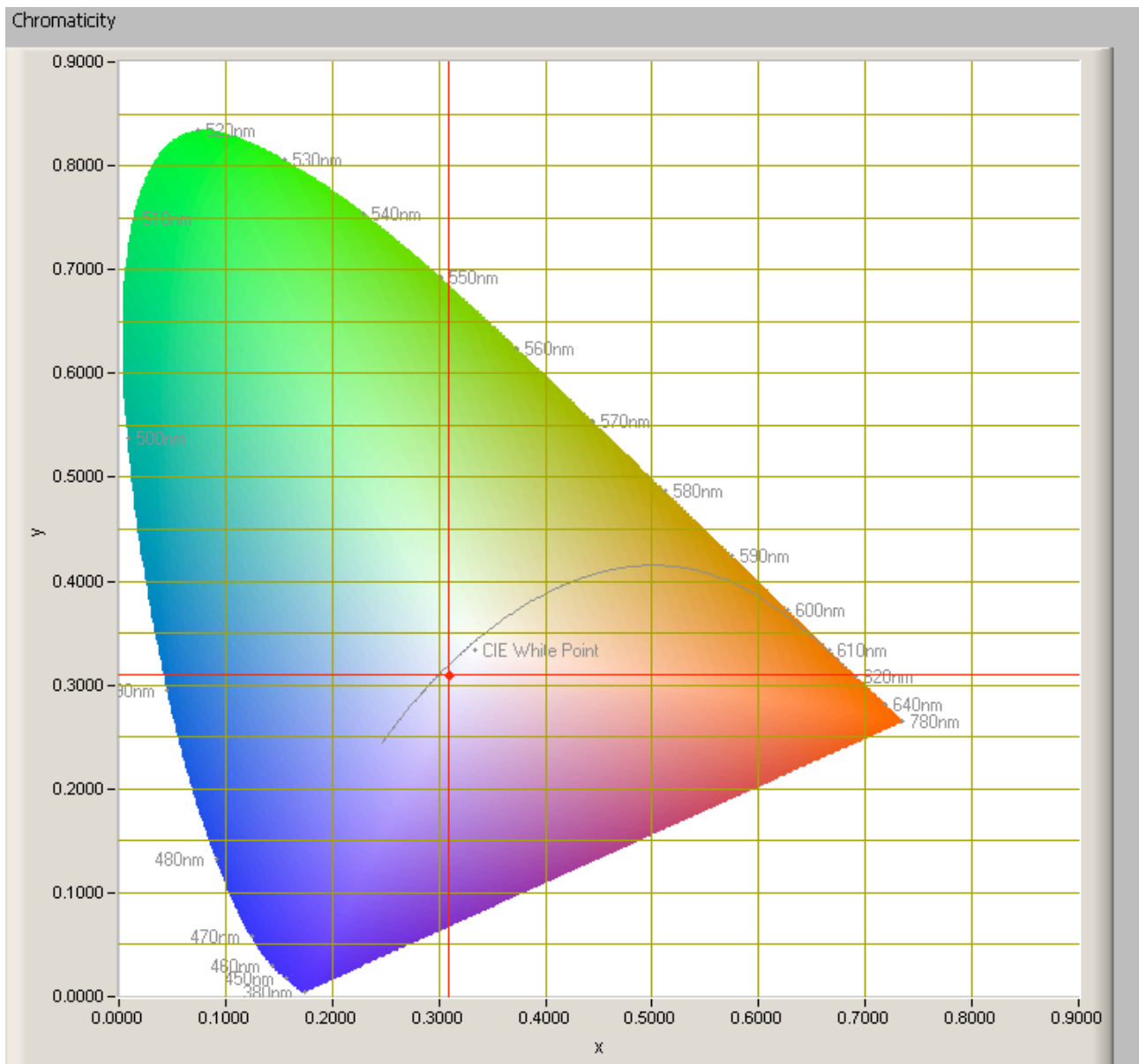
Multiplying these two results in a curve showing the number of photos per wave length of the light of this light bulb, the PAR spectrum.

Summing all the photons, gives a PAR number that for this light results in 2.61 $\mu\text{Mol/s/m}^2$.

Lamp measurement report – 15 June 2009 for Led Light Europe

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 66 % (valid for the PAR wave length range of 400 - 725 nm). So 66 % of the photons is effectively used by the average plant.

Chromaticity diagram



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

Lamp measurement report – 15 June 2009 for Led Light Europe

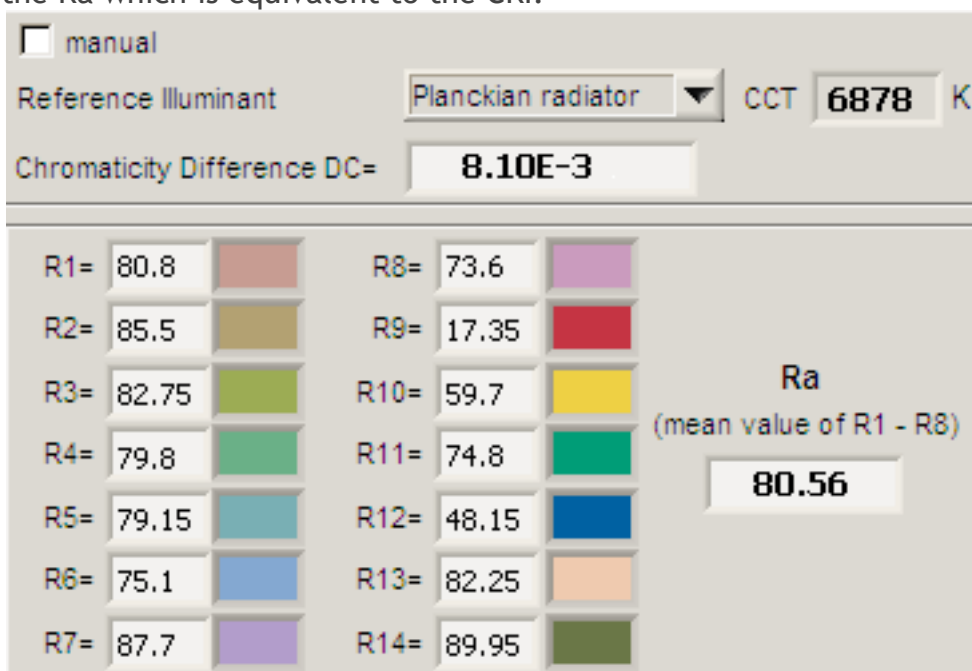
The light coming from this lamp is a little below the Planckian Locus (the black path in the graph).

Its coordinates are $x=0.3094$ and $y=0.3104$.

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 R_x , and the first 8 indexes (R1 .. R8) are averaged to compute the Ra which is equivalent to the CRI.



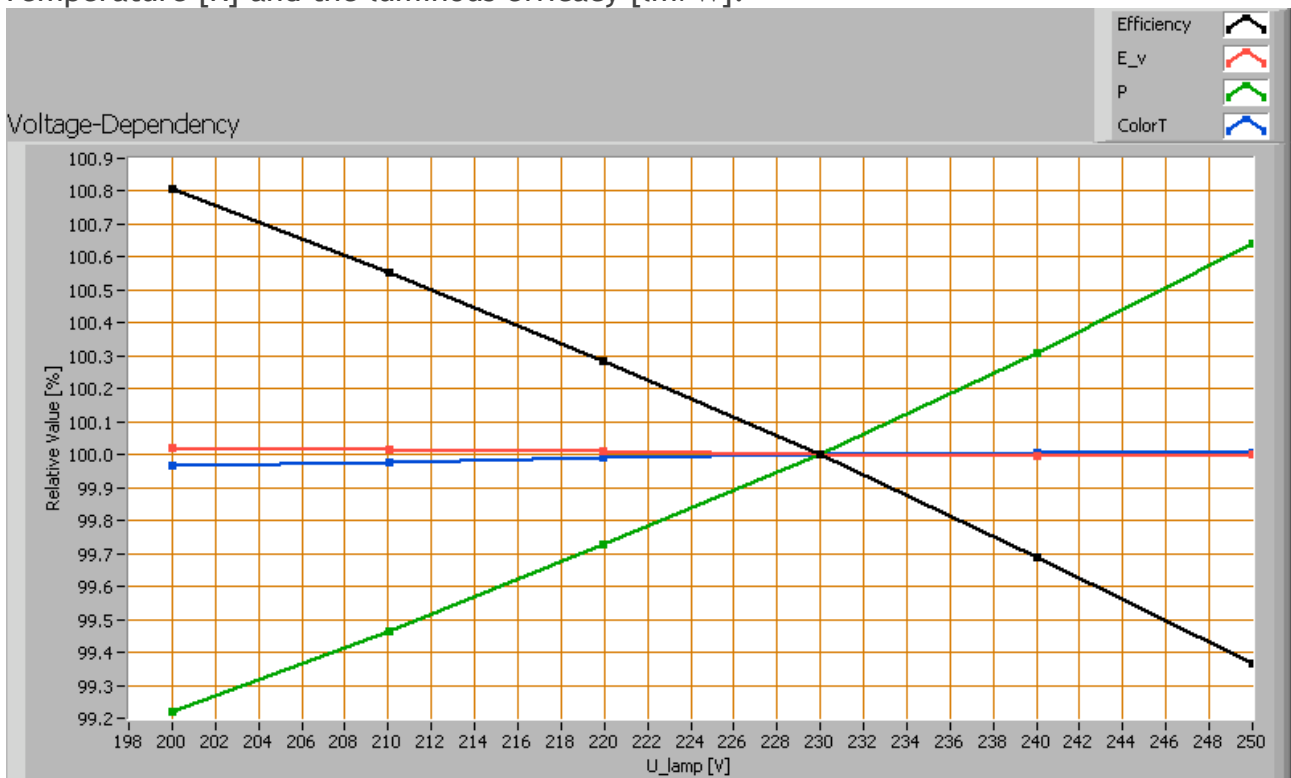
CRI of the light of this lightbulb.

The value of 81 is higher than 80 which is considered a minimum value for indoor usage. Note: the chromaticity difference is 0.0081 indicates the distance to the Planckian Locus. Its value is higher than 0.0054, which means that the calculated CRI result is not meaningful.

Lamp measurement report – 15 June 2009 for Led Light Europe

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 lamp parameters measured: illuminance E_v [lx], the lamp power P [W], the (Correlated) Color Temperature [K] and the luminous efficacy [lm/W].



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

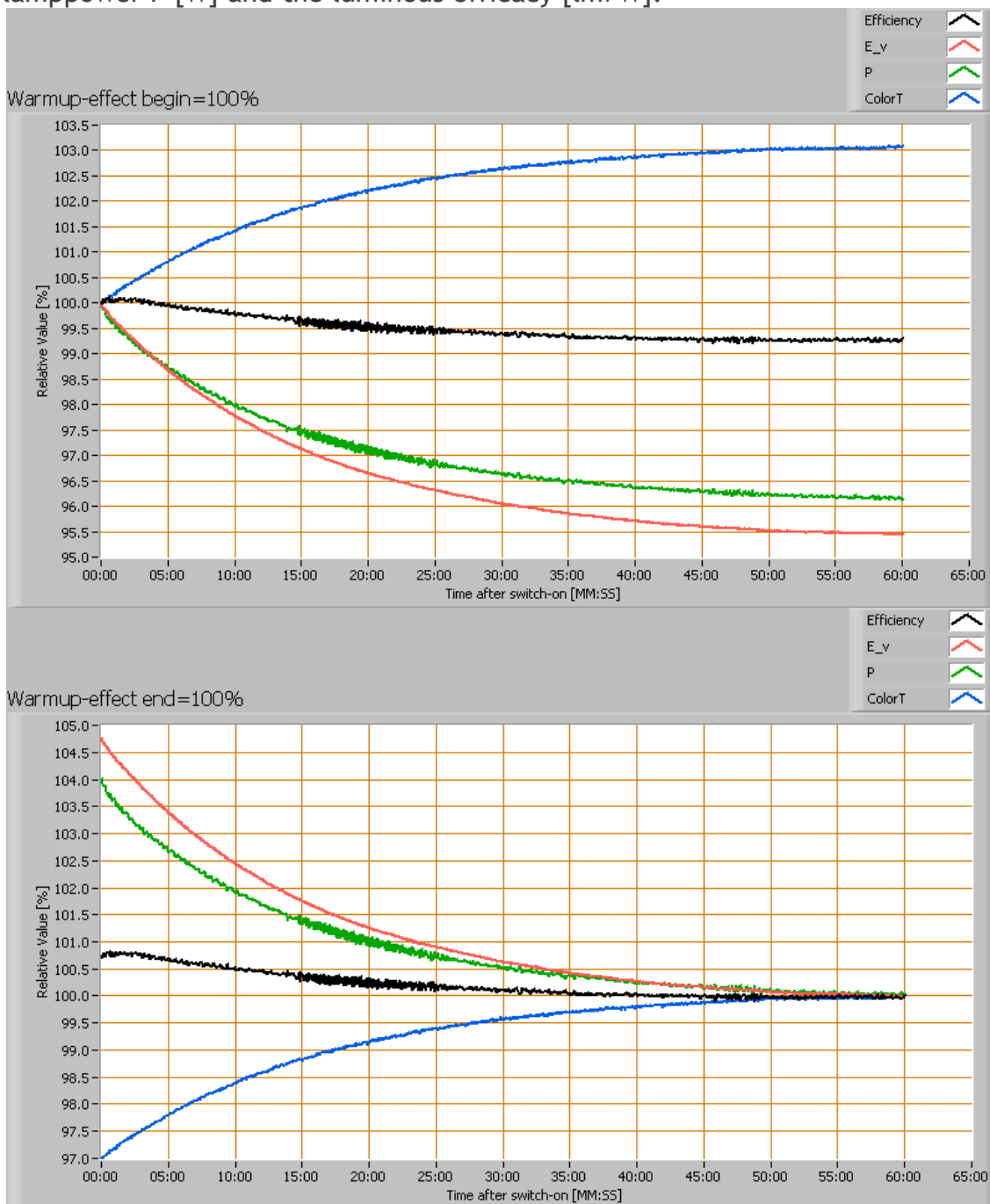
There is no significant variation of parameters when the voltage varies in the 200 - 250 V range.

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

Lamp measurement report – 15 June 2009 for Led Light Europe

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



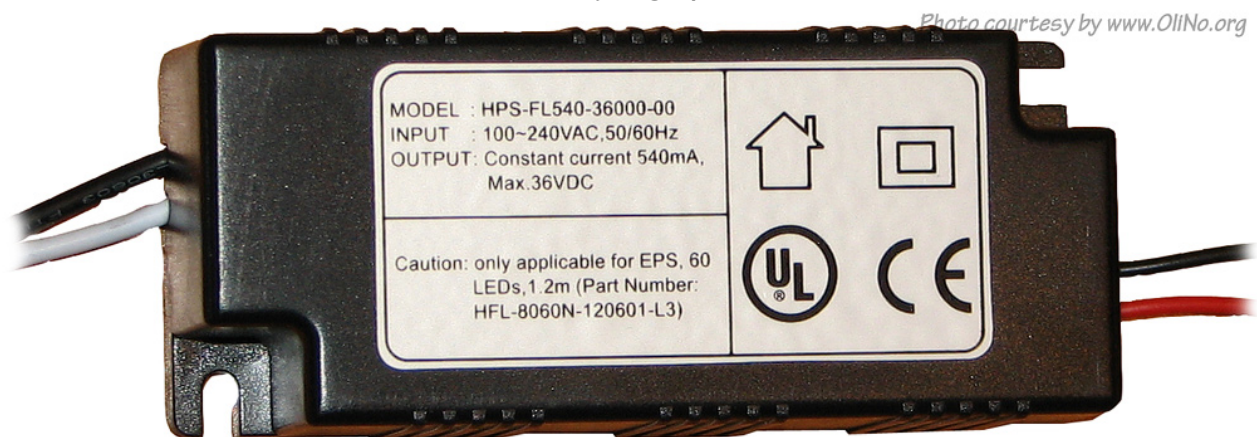
Lamp measurement report – 15 June 2009 for Led Light Europe

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

The warm-up time is not relevant as the variation in parameters is maximally 5 %.

Current source driver

This tube needs a constant current and must therefore be connected to a specific current source. The one used in this article, that was delivered with the tube, is presented here. It does the job of converting the energy of the grid at grid voltage into a constant current for the leds, with a very high power factor.



The used constant current driver for this led tube light.

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