



Lamp measurement report – 12 Aug 2009

20W TL 324 smd LED Warm White

by

Simplify-It



Photo courtesy by www.OliNo.org

Lamp measurement report – 12 Aug 2009

Summary measurement data

parameter	meas. result	remark
Color temperature	3378 K	Warm white, still on the cool side of warm white.
Luminous intensity I_v	409 Cd	Measured straight underneath the light bulb.
Beam angle	102 deg	
Power P	15.1 W	
Power Factor	0.34	For every 1 kWh net power consumed, there has been 2.8 kVAhr for reactive power.
Luminous flux	1070 lm	
Luminous efficacy	71 lm/W	What actually is meant here is luminaire efficacy, this accounts for all driver, thermal and luminair optical losses.
CRI_Ra	65	Color Rendering Index.
Coordinates chromaticity diagram	x=0.4178 and y=0.4085	
Fitting	FL-tube	
PAR-value	3.5 $\mu\text{Mol/s/m}^2$	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.
S/P ratio	1.2	This factor of higher efficacy when used in very low light circumstances.
D x L external dimensions	32 x 1200 mm	External dimensions of the light bulb.
L x W luminous area	1175 x 25 mm	Dimensions of the luminous area (used in Eulumdat file). This is equal to the surface of the place the leds are mounted on.
General remarks		<p>The ambient temperature during the whole set of measurements was 27 deg C.</p> <p>Warm up effect: during the warm up time the illuminance decreased with 11 %.</p> <p>Voltage dependency: the power consumption depends on the voltage applied.</p>

Lamp measurement report – 12 Aug 2009

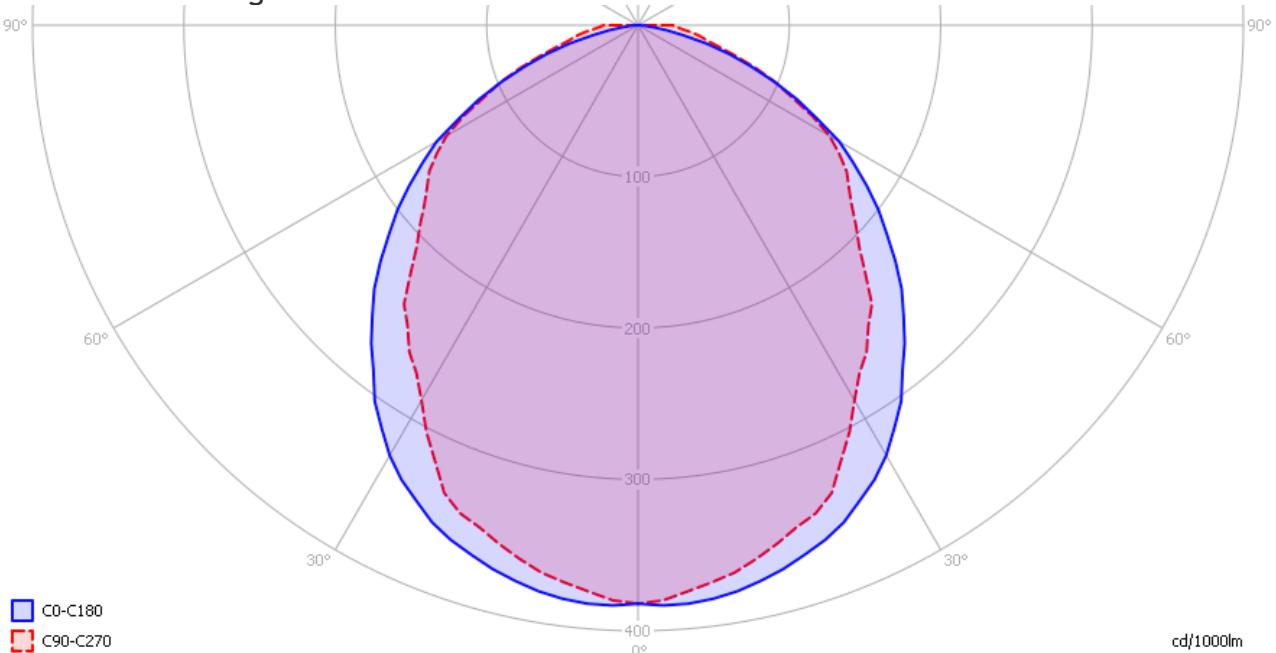
Overview table

m.	\emptyset 50%	102°	E (lux)	Efficacy
0.25	0.62		6544	71 (lumens per Watt)
0.5	1.24		1636	Half Peak Diameter
1	2.48		409	2.48 x diameter(m)
1.5	3.72		182	Illuminance
3	7.44		45	409 / distance ² (lux)
				Total Output
				1070 (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.



Lamp measurement report – 12 Aug 2009

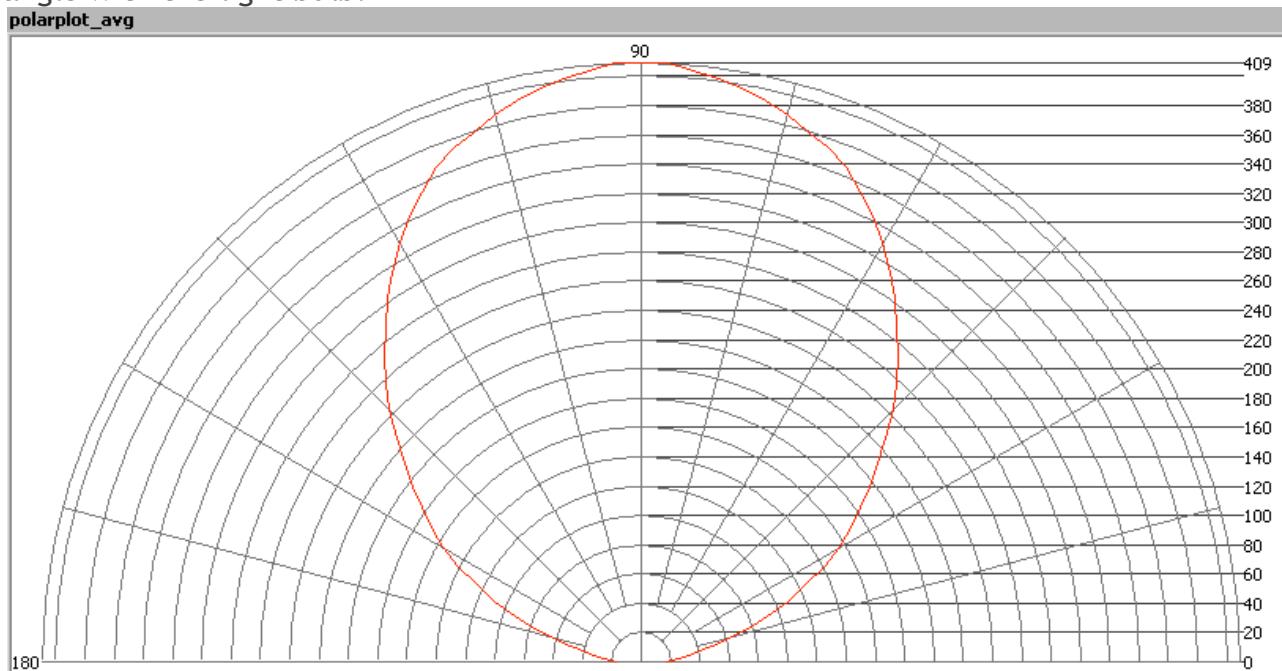
The light diagram giving the radiation pattern.

It indicates the luminous intensity around the light bulb. This light bulb has a different light diagram for the C0-C180 plane (in length direction of the tube) than for the C90-C270 plane (perpendicular to the length direction). The beam of light produced is quite common for Tube Lights.

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.

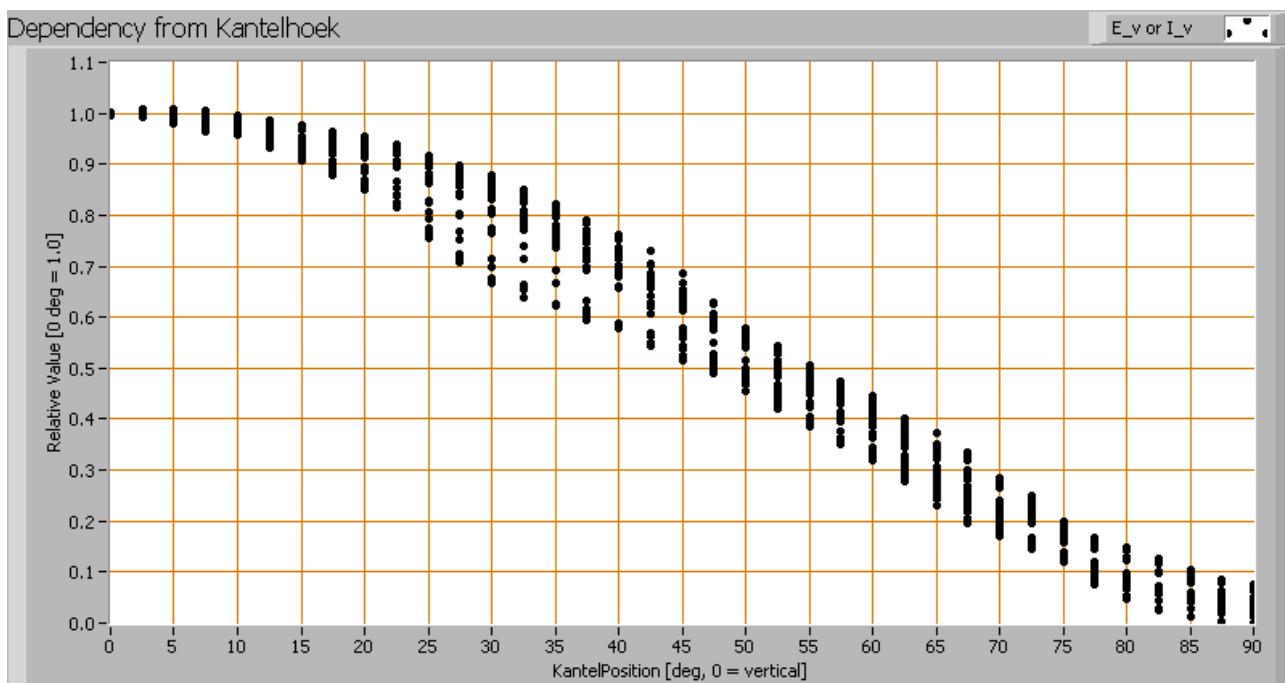


The radiation pattern of the light bulb.

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 – 12 Aug 2009



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. When using the average values per inclination angle, the beam angle can be computed, being 102 degrees. This is the average value, the actual value for the C0-C180 plane is somewhat smaller and for the C90-C270 plane it is somewhat bigger, as can be seen from the Eulumdat light diagram.

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 1070 lm.

Luminous efficacy

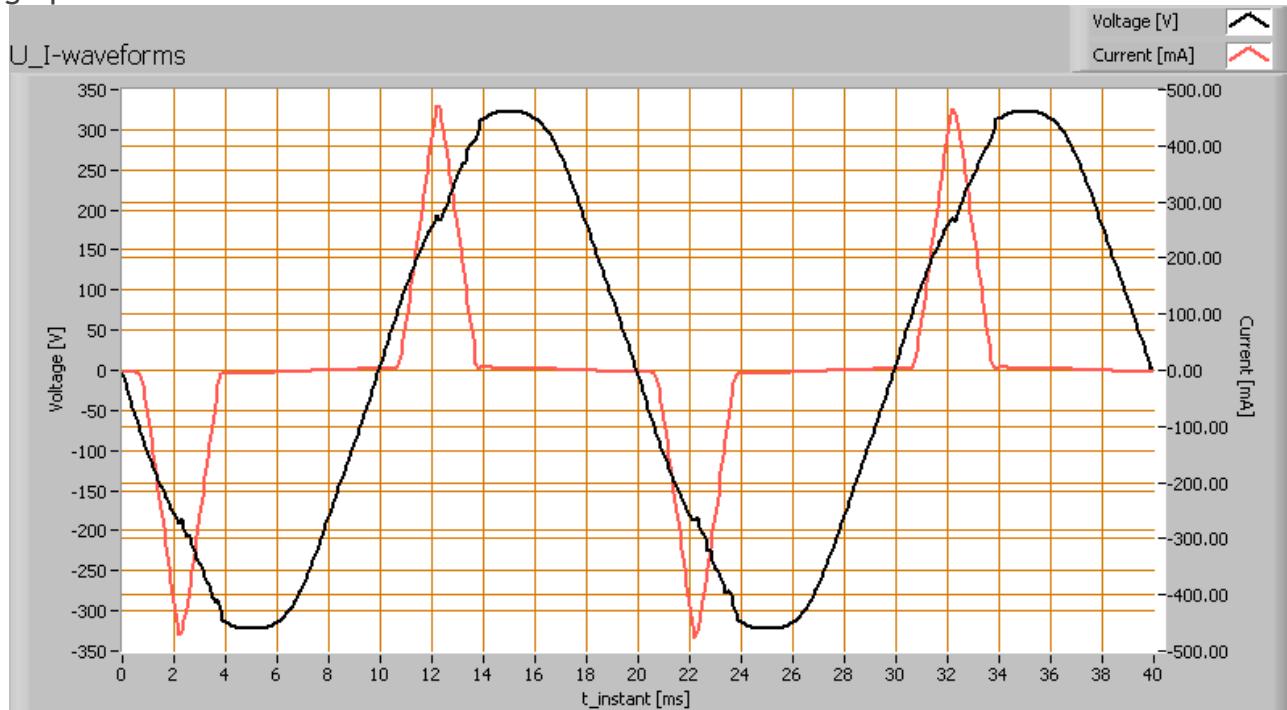
The luminous flux being 1070 lm, and the power of the light bulb being 15.1 W, yields a luminous efficacy of 71 lm/W.

Lamp measurement report – 12 Aug 2009

A power factor of 0.34 means that for every 1 kWh net power consumed, a reactive component of 2.8 kVAr was needed.

Light bulb voltage	230 VAC
Light bulb current	195 mA
Power P	15.1 W
Apparent power S	44.9 VA
Power factor	0.34

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

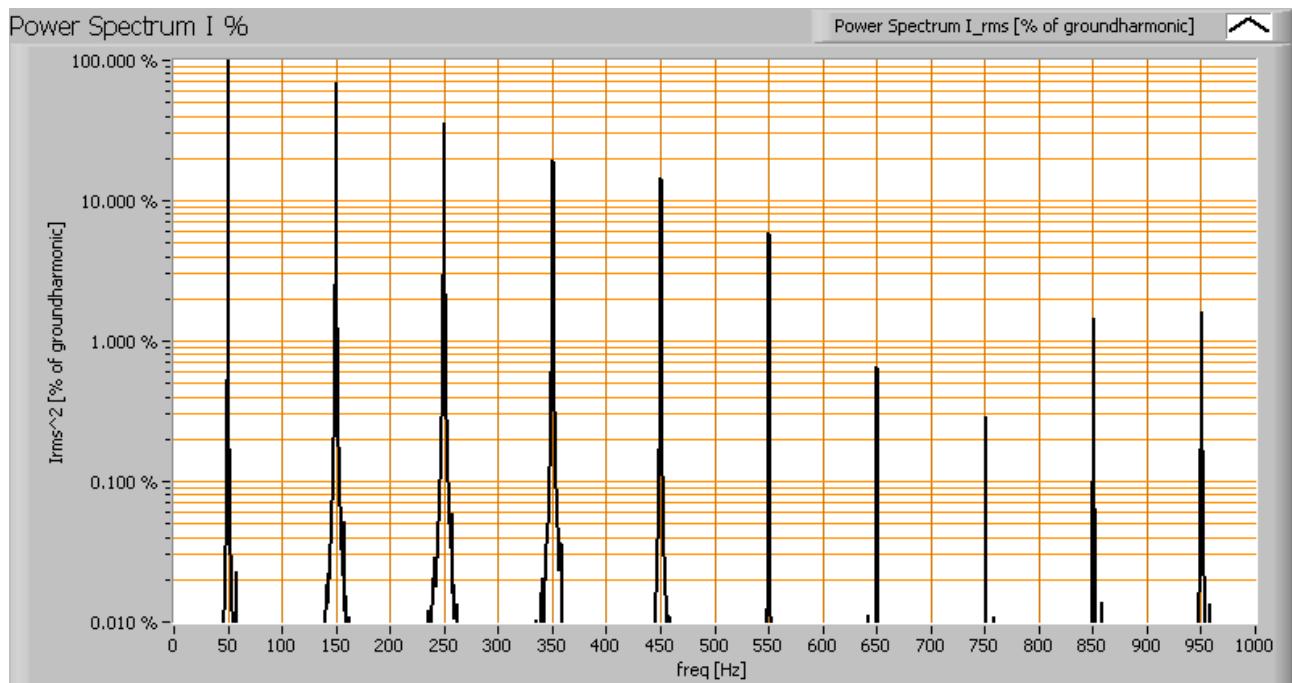


Voltage across and current through the lightbulb

The current is not in phase with the voltage and has not a sinusoidal form. Hence the power factor is low.

Also the power spectrum of the current is determined.

Lamp measurement report – 12 Aug 2009

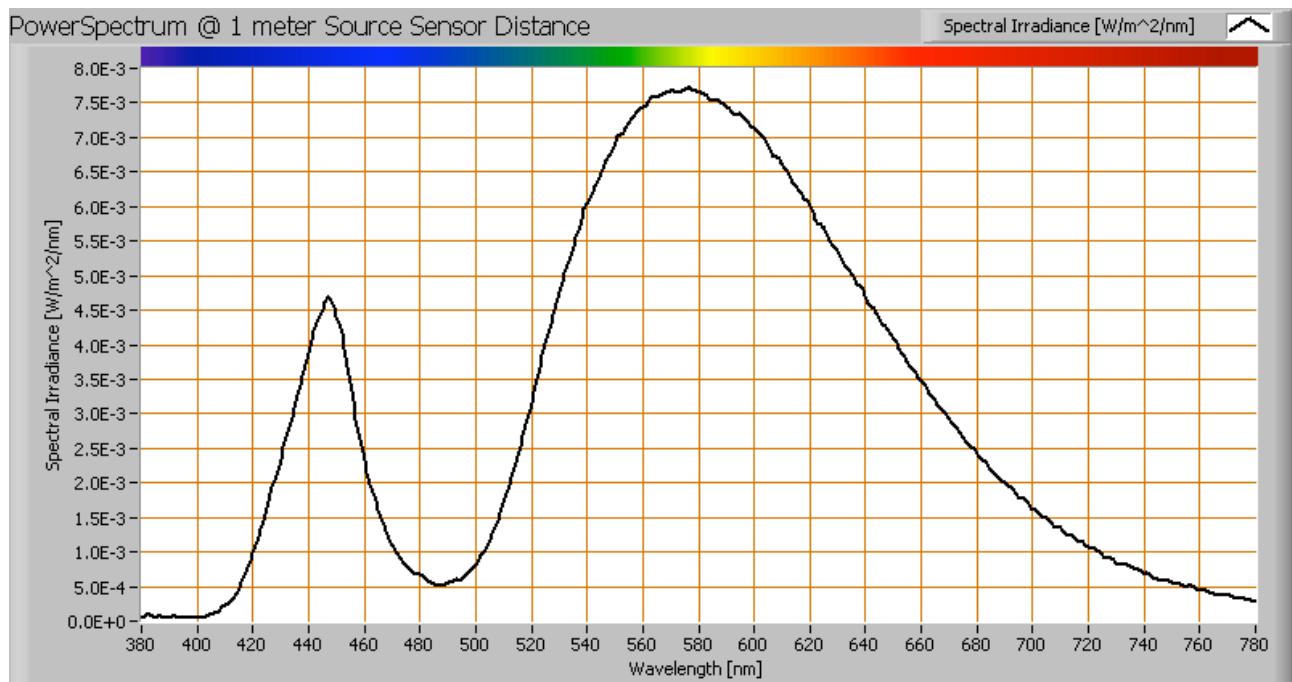


Current power spectrum in % of the first harmonic (50 Hz).

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

Lamp measurement report – 12 Aug 2009

Color temperature and Spectral power distribution

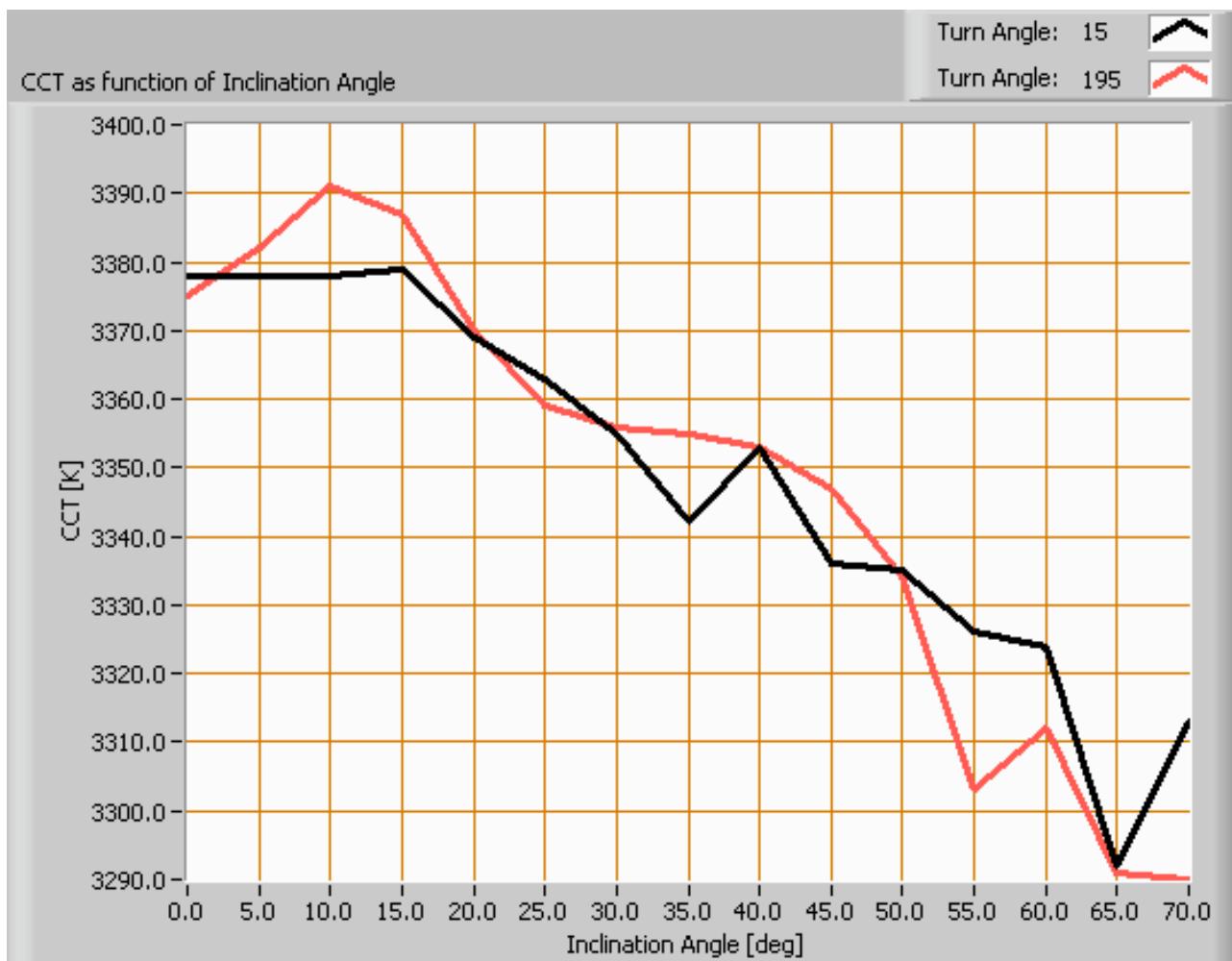


The spectral power distribution of this light bulb, energies on y-axis valid at 1 m distance.

The measured color temperature is about 3375 K which is on the cool side of warm 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 – 12 Aug 2009



Color temperature as a function of inclination angle.

The beam angle is 102 degrees, meaning at an inclination angle of 51 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 variation in light color is about 2 % of its value at 0 degrees inclination angle.

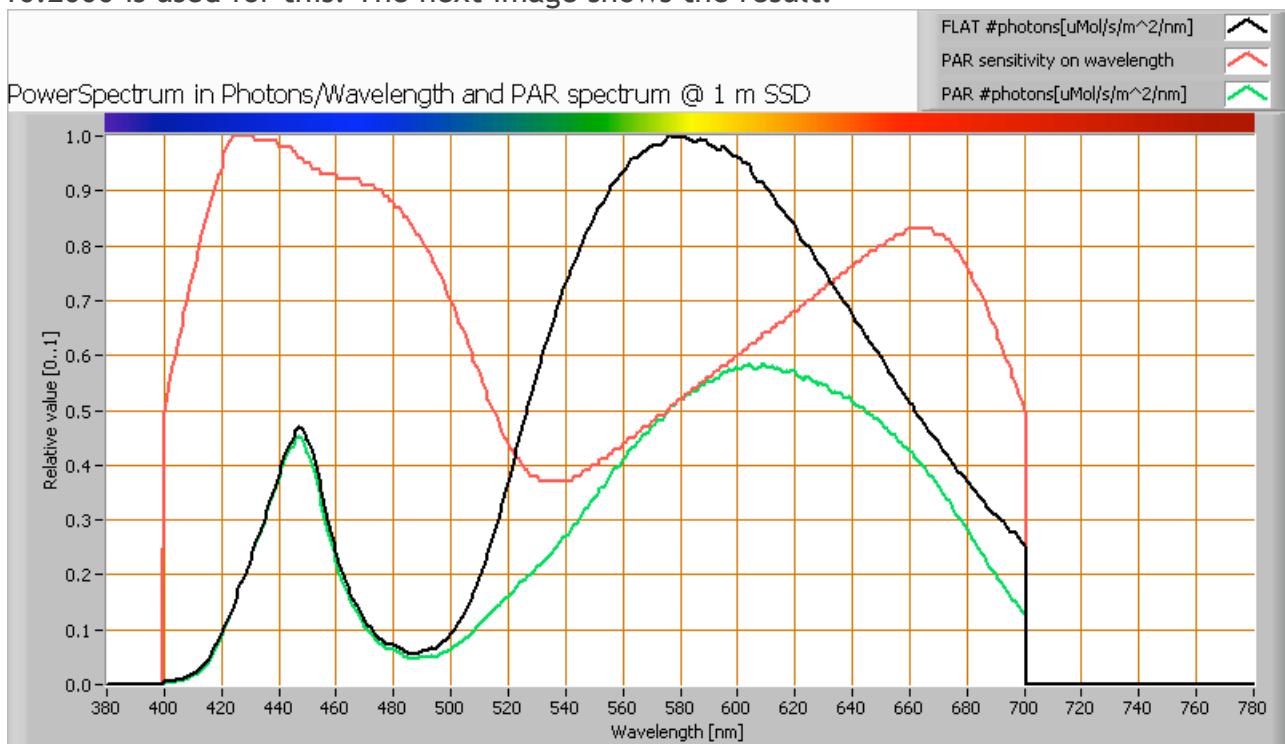
PAR value and PAR spectrum

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 $\mu\text{Mol}/\text{s}/\text{m}^2$. Photosynthesis is the essence for growth and flowering of plants, where the blue part of

Lamp measurement report – 12 Aug 2009

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 photons 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 $3.5 \mu\text{Mol/s/m}^2$. This value is valid at 1 m distance from the light bulb.

Lamp measurement report – 12 Aug 2009

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 62 % (valid for the PAR wave length range of 400 - 725 nm). So maximally 62 % 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 %).

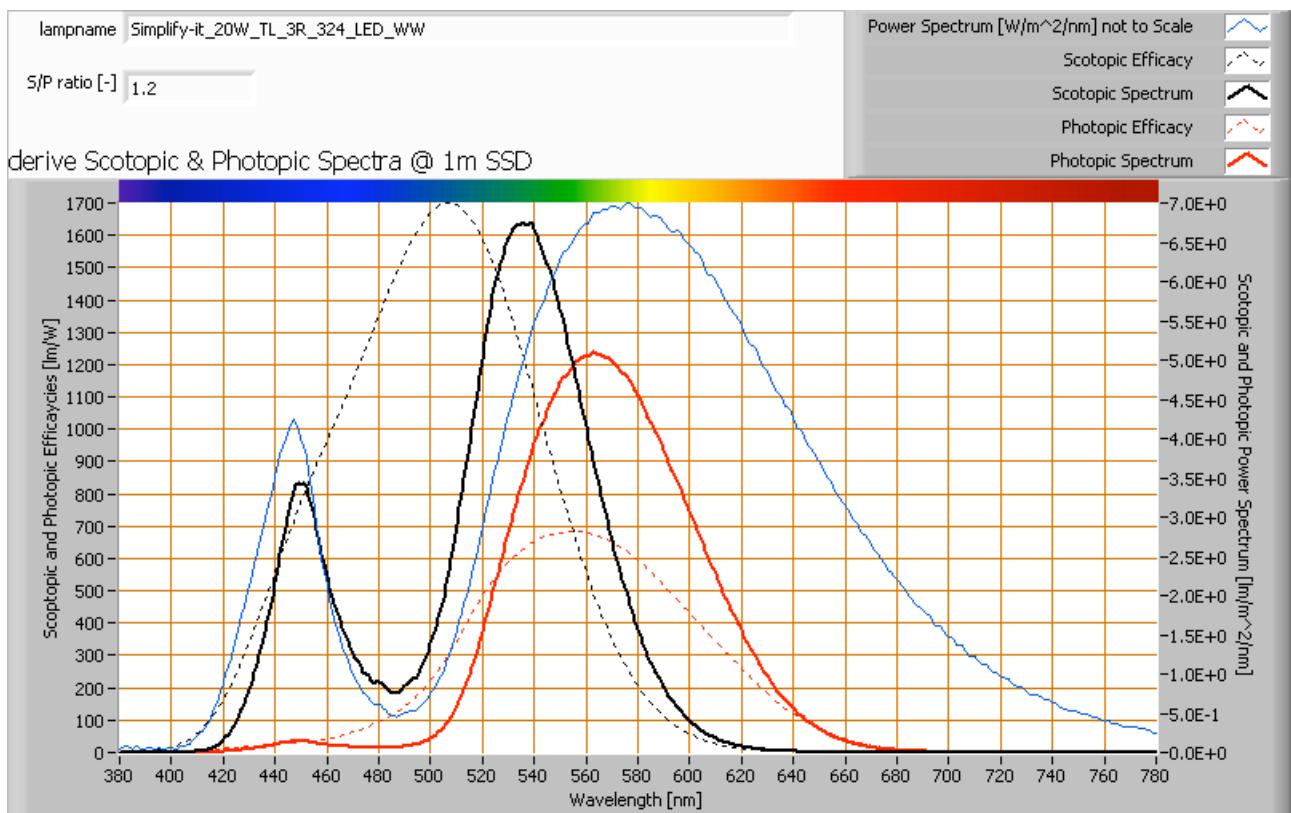
Note: when mentioning this percentage of efficiency, it is important to verify if all wavelengths are present in a sufficient manner. Not that only blue light is available, when the plant is going to be used for flowering where specifically red light is needed.

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 1.2. The light of this lightbulb at scotopic light levels is perceived this factor higher than it would be a photopic light levels.

Lamp measurement report – 12 Aug 2009

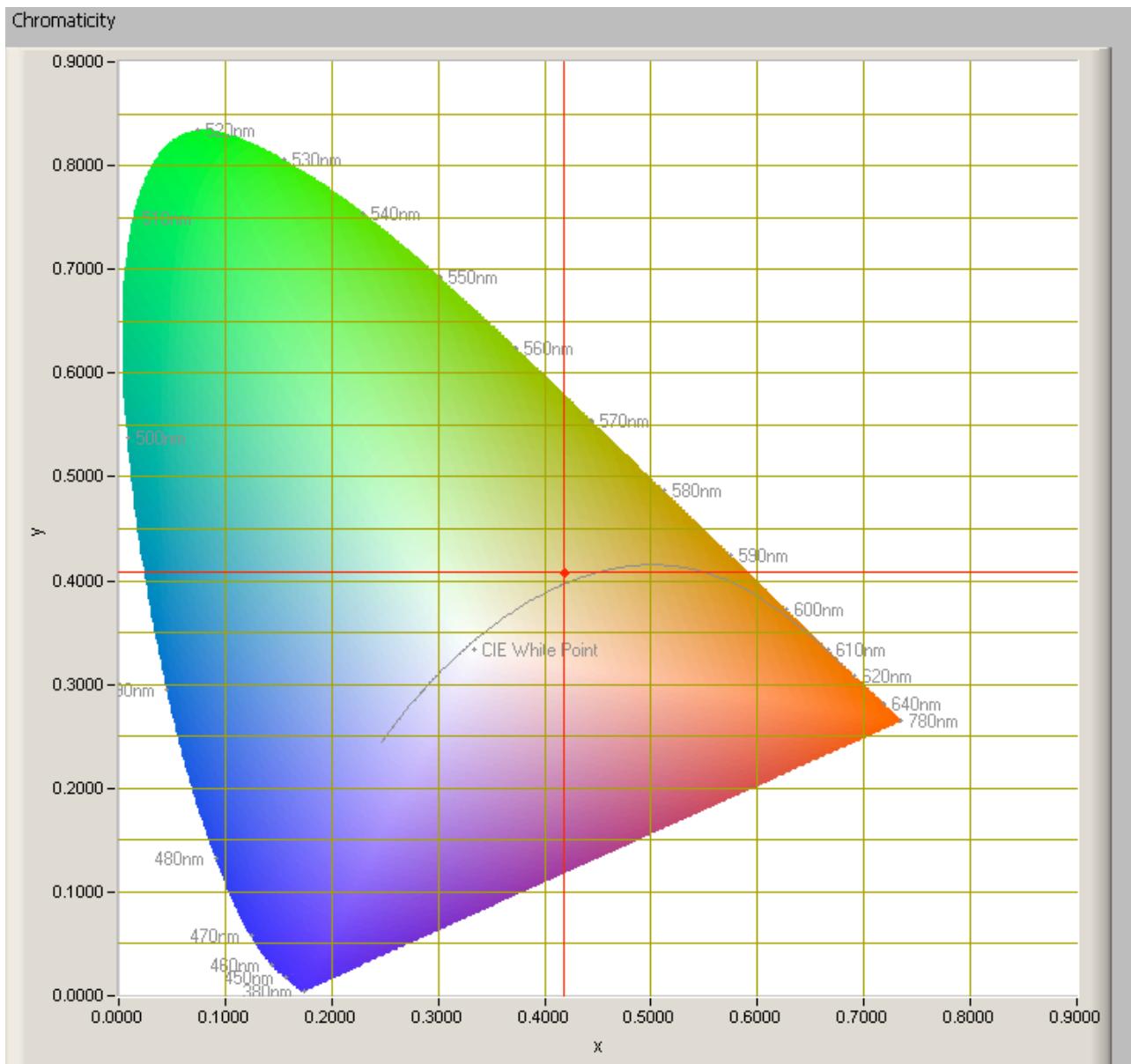


The power spectrum, sensitivity curves and resulting scotopic and photopic spectra (spectra energy content defined at 1 m distance).

Since there is a lot of red and yellow in the spectrum and not too much blue, the S/P ratio is not big.

Lamp measurement report – 12 Aug 2009

Chromaticity diagram



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

The light coming from this lamp op top of the Planckian Locus (the black path in the graph).

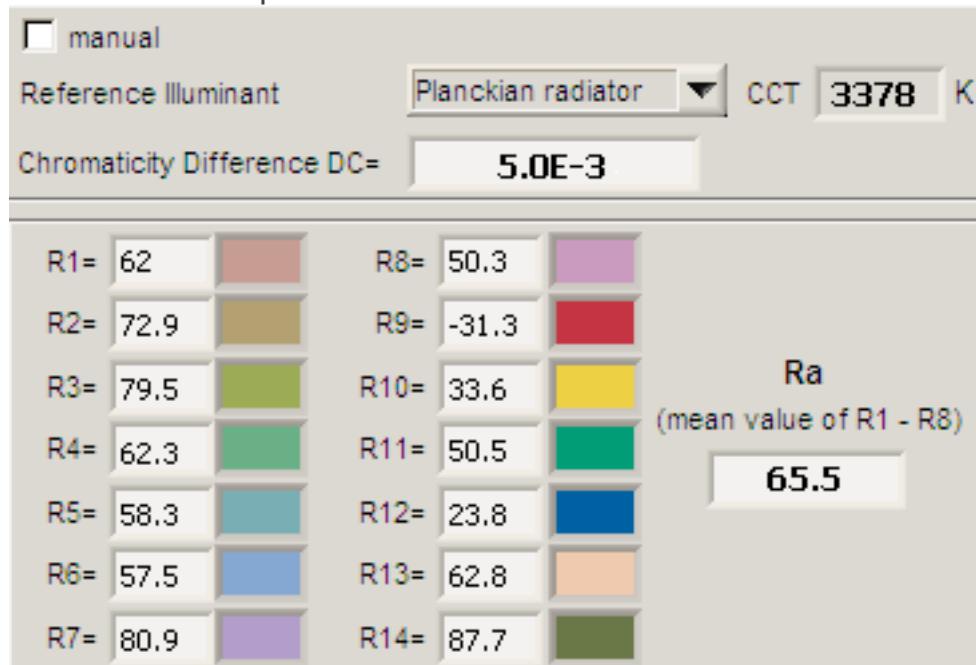
Its coordinates are x=0.4178 and y=0.4085.

Lamp measurement report – 12 Aug 2009

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.

The value of 66 is lower than 80 which is considered a minimum value for indoor usage.

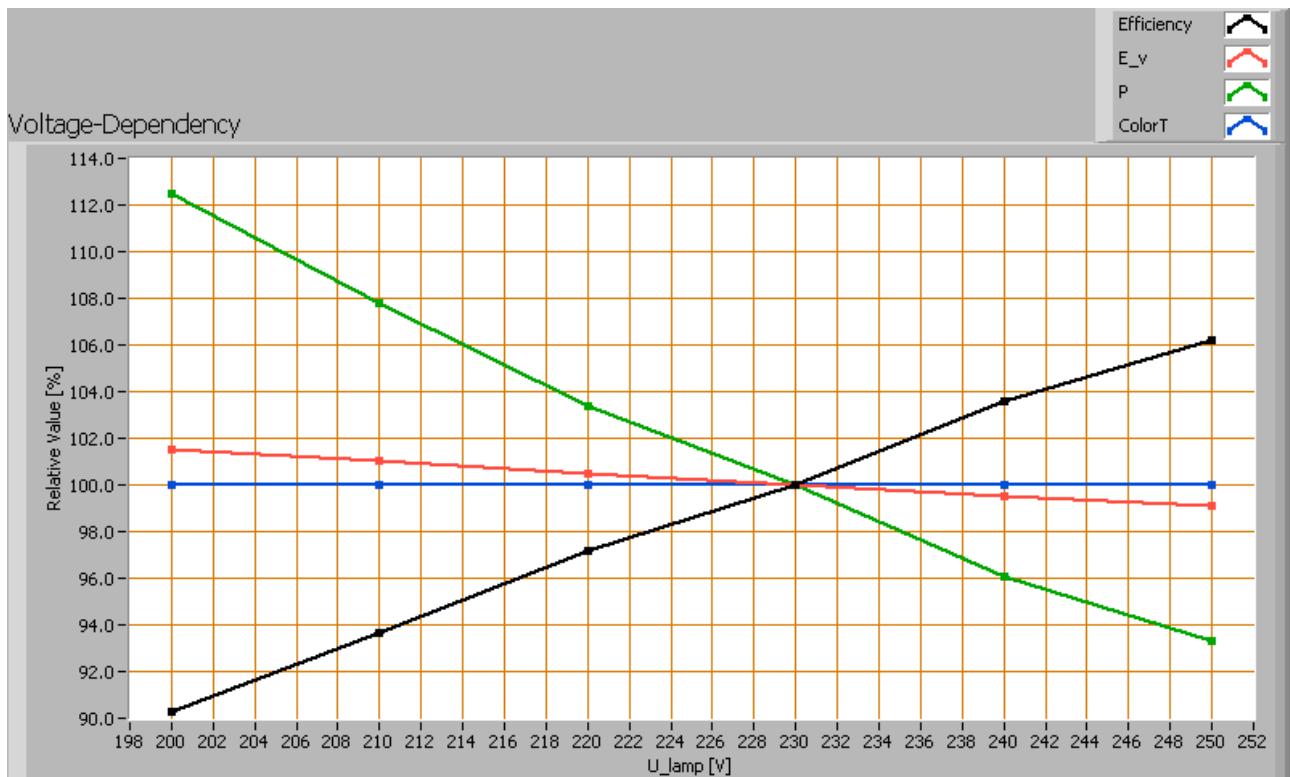
Note: the chromaticity difference is 0.005 indicates the distance to the Planckian Locus.

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].

Lamp measurement report – 12 Aug 2009



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

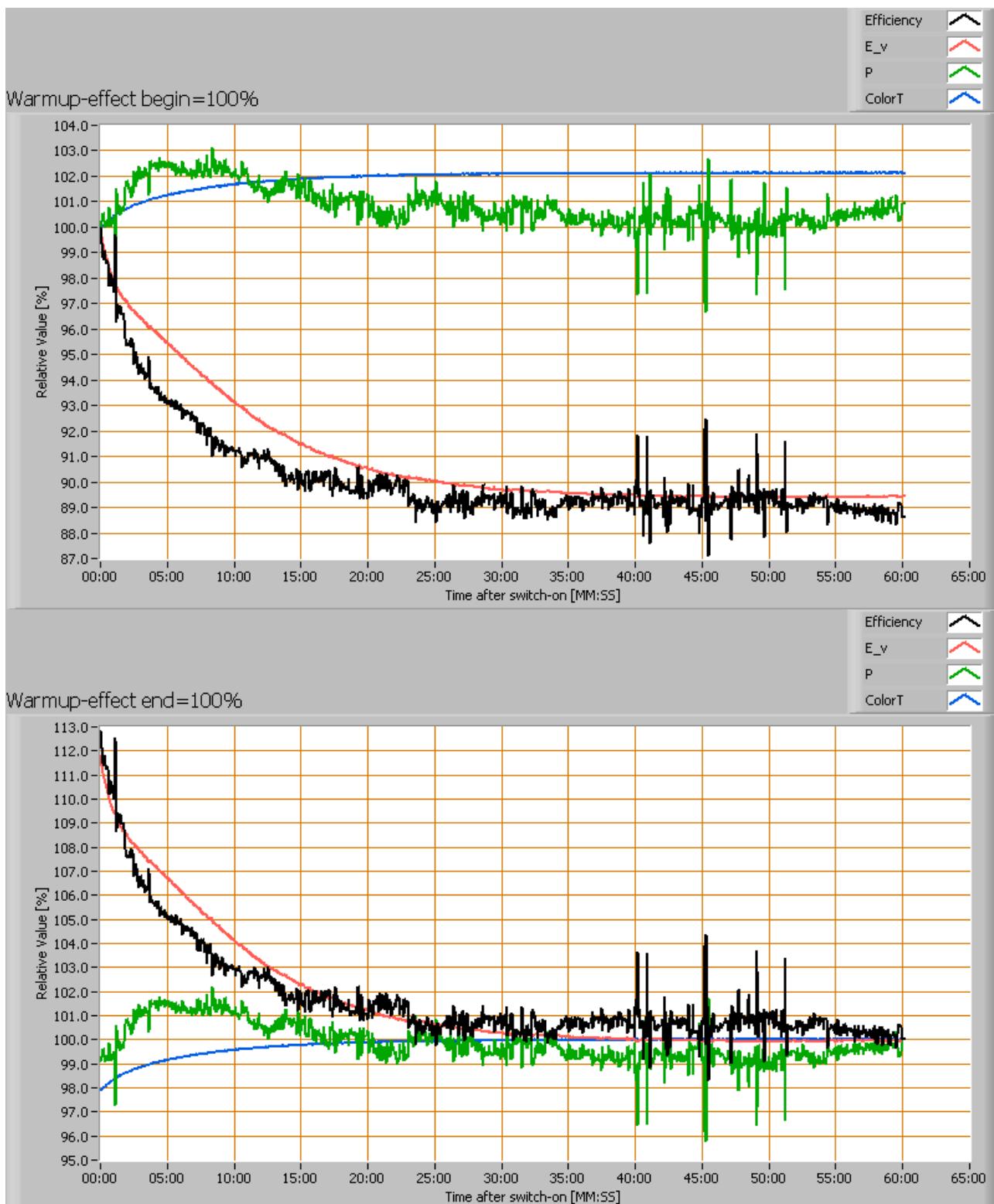
The consumed power varies when the voltage varies between 200-250 V. The variation is linearly.

When the voltage at 250 V varies with + and - 5 V, then the illuminance varies within 0.5 %, 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].

Lamp measurement report – 12 Aug 2009



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



Lamp measurement report – 12 Aug 2009

The warm-up time is about 20 minutes, during which the illuminance decreases with 11 %.

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