

Lamp measurement report – 1 July 2009 for Leds Light The World BV

Leds Light The World BV LED Tube 120cm CW






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Summary measurement data

| parameter | meas. result | remark |
|----------------------------------|---------------------------|--|
| Color temperature | 6886 K | Cold white. |
| Luminous intensity I_v | 388 Cd | |
| Beam angle | 121 deg | |
| Power P | 16.1 W | |
| Power Factor | 0.55 | For every 1 kWh net power consumed, there has been 1.5 kVAhr for reactive power. |
| Luminous flux | 1247 lm | |
| Luminous efficacy | 77 lm/W | |
| CRI_Ra | 79 | Color Rendering Index. |
| Coordinates chromaticity diagram | x=0.3080 and y=0.31423169 | |
| Fitting | FL-tube | |
| PAR-value | 3.7 $\mu\text{Mol/s/m}^2$ | 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. |
| D x L external dimensions | 31 x 1200 mm | External dimensions of the light bulb. This excludes the pins. |
| W x L luminous area | 23 x 1117 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 27 deg C.</p> <p>Warm up effect: during the warm up time the illuminance decreases with 10 % and the consumed power with 7 %.</p> <p>Voltage dependency: the power consumption and illumination are not significantly dependent from the used voltage.</p> <p>See at the end of this article a close up of the leds.</p> |
| | | |

Lamp measurement report – 1 July 2009 for Leds Light The World BV

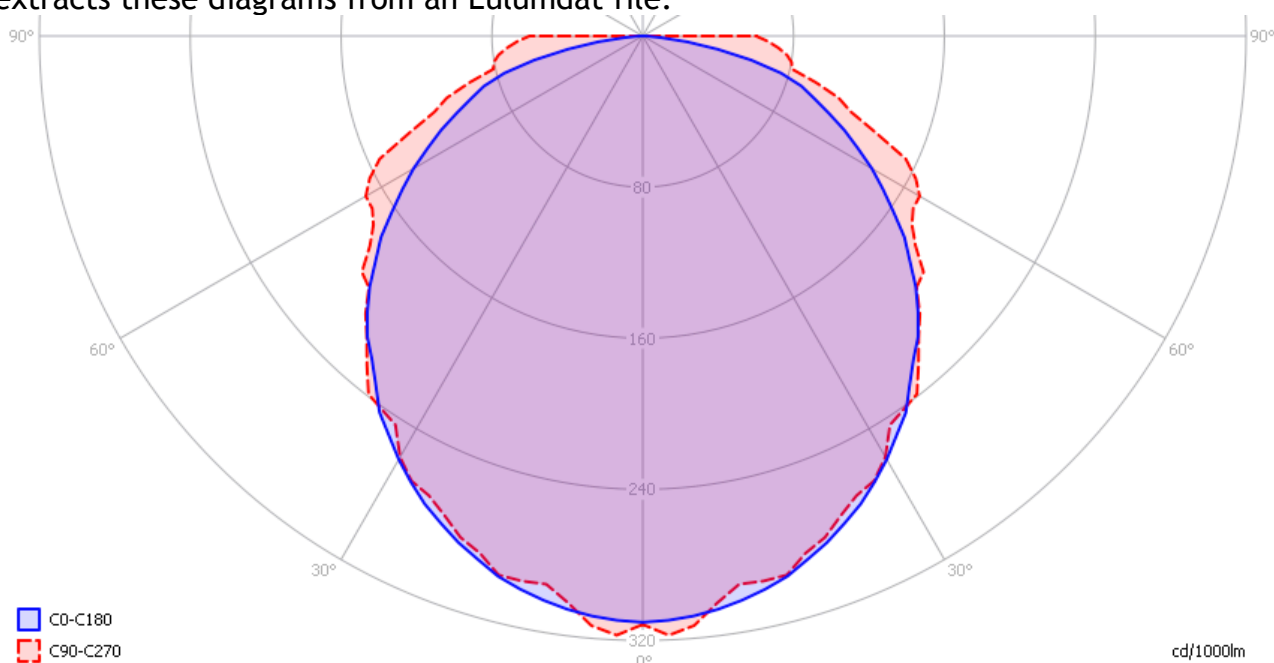
Overview table

| m. | Ø 50% | 121° | E (lux) | Efficacy |
|------|-------|---|---------|-----------------------------------|
| 0.25 | 0.88 |  | 6206 | 77 (lumens per Watt) |
| 0.5 | 1.75 | | 1551 | Half Peak Diameter |
| 1 | 3.51 | | 388 | 3.51 x diameter(m) |
| 1.5 | 5.26 | | 172 | Illuminance |
| 3 | 10.52 | | 43 | 388 / distance ² (lux) |
| | | | | Total Output |
| | | | | 1247 (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 – 1 July 2009 for Leds Light The World BV

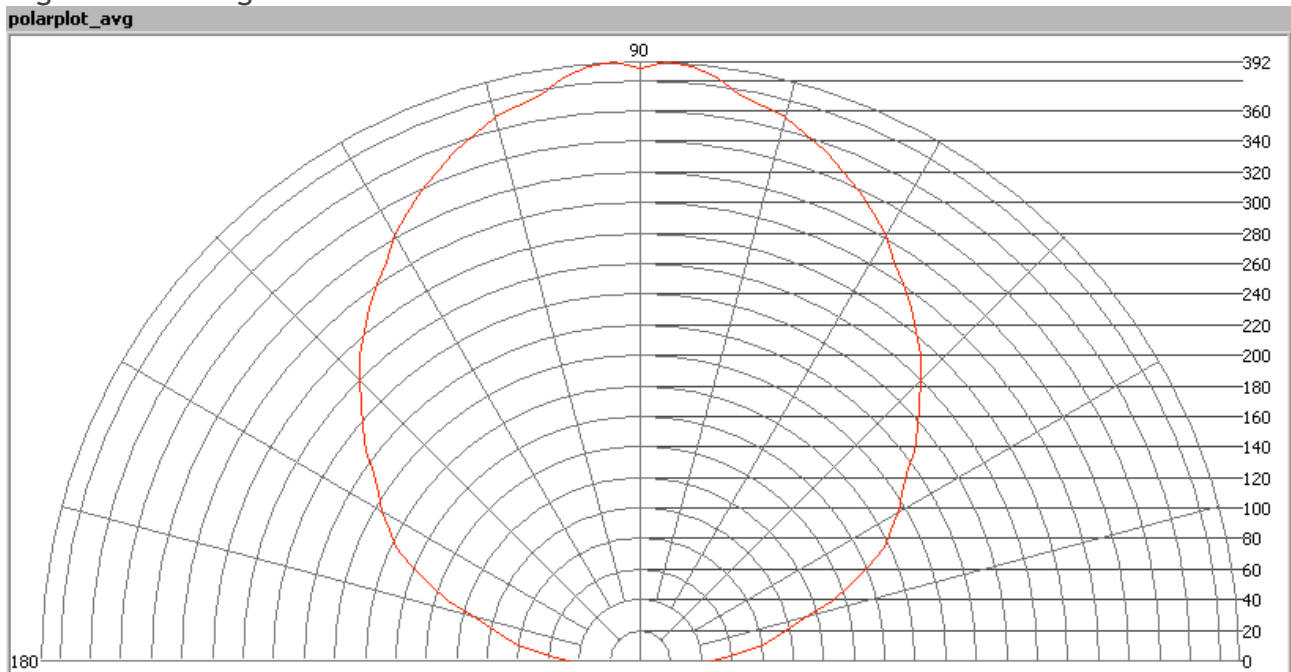
It indicates the luminous intensity around the light bulb. The C0-C180 plane is along the length of the tube light and the C90-C270 perpendicular to that.

The bundle widths are essentially the same for both planes.

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.

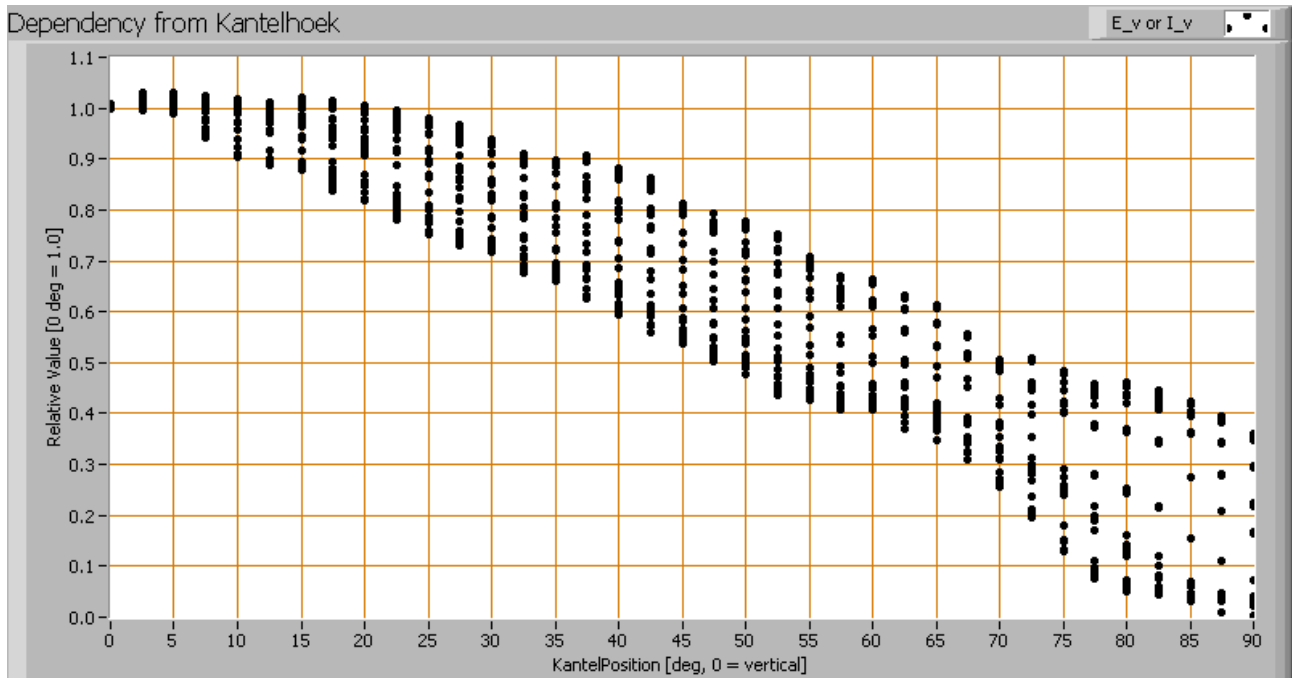


The radiation pattern of the light bulb.

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 – 1 July 2009 for Leds Light The World BV



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 121 degrees. This is the average value which is assumably valid for all C-planes, as it has been shown that both C0-C180 and C90-C270 planes have essentially the same beam angle.

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 1247 lm.

Luminous efficacy

The luminous flux being 1247 lm, and the power of the lightbulb being 16.1 W, yields a

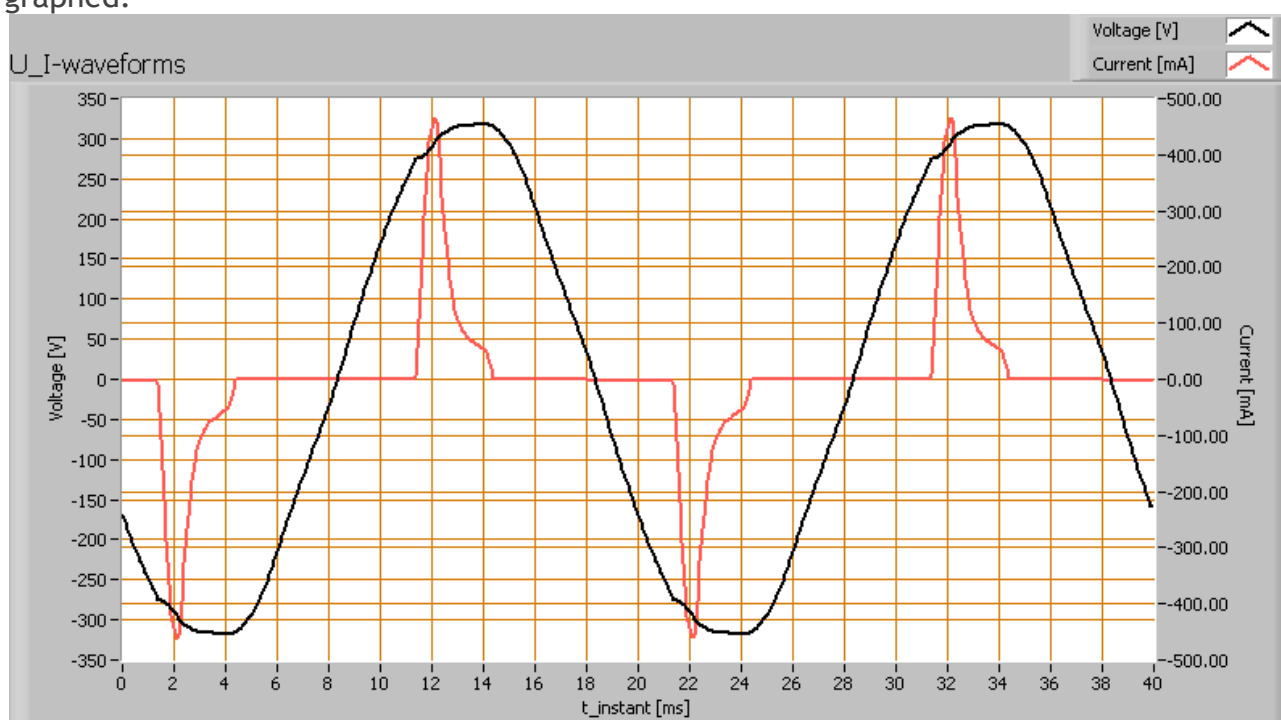
Lamp measurement report – 1 July 2009 for Leds Light The World BV

luminous efficacy of 77 lm/W.

A power factor of 0.55 means that for every 1 kWh net power consumed, a reactive component of 1.5 kVar was needed.

| | |
|--------------------|---------|
| Light bulb voltage | 230 VAC |
| Light bulb current | 126 mA |
| Power P | 16.1 W |
| Apparent power S | 29 VA |
| Power factor | 0.55 |

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

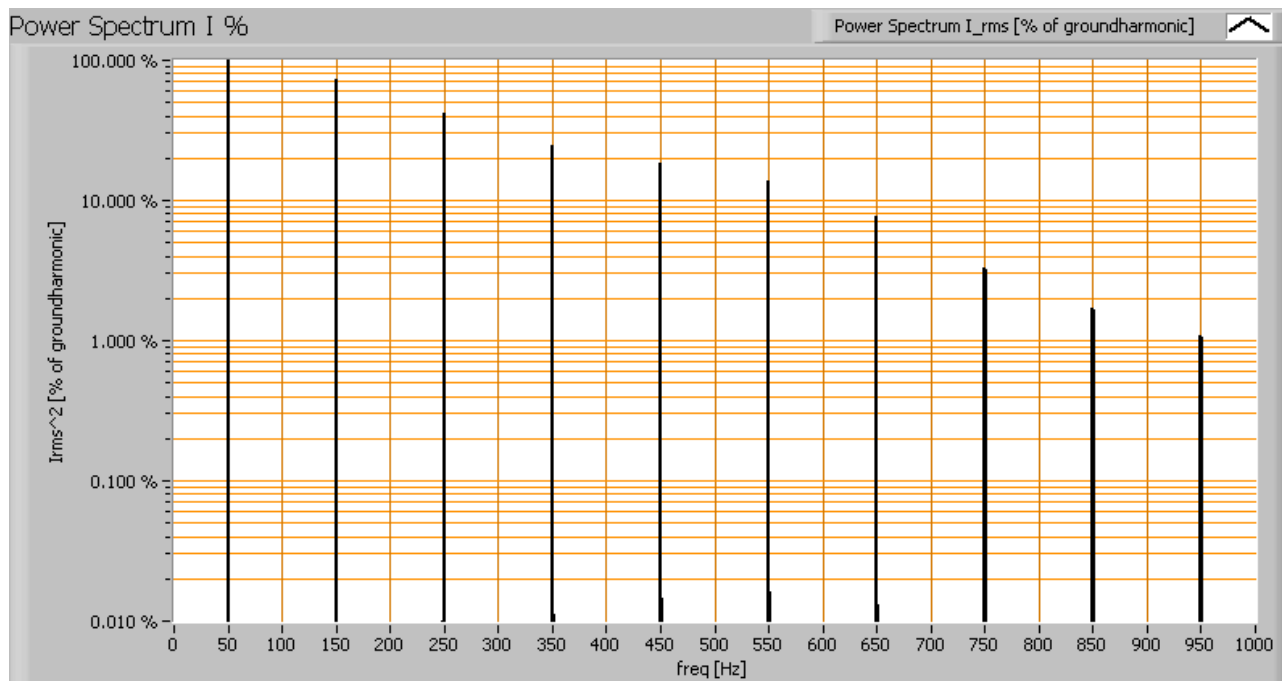


Voltage across and current through the lightbulb

The current driver is built such that it requires peak current to realise the power conversion from grid voltage to current needed for the leds. These peaks are not symmetrical, nor are the of the sinusoidal form of the voltage that is put over the light bulb. Result is that the power factor is significantly lower than 1 and there is harmonic content in the cpectrum of the current due to the peaks.

Also the power spectrum of the current is determined.

Lamp measurement report – 1 July 2009 for Leds Light The World BV

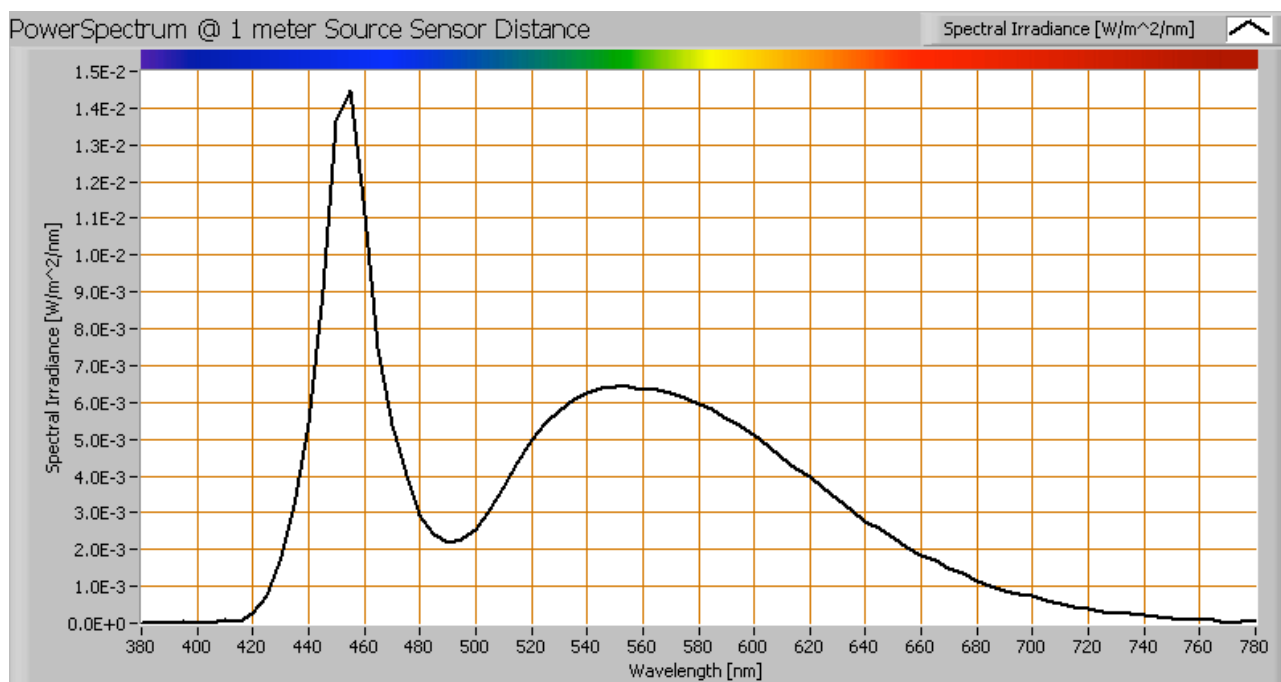


Current power spectrum in % of the first harmonic (50 Hz).

Noticeable are the higher harmonics.

Lamp measurement report – 1 July 2009 for Leds Light The World BV

Color temperature and Spectral power distribution

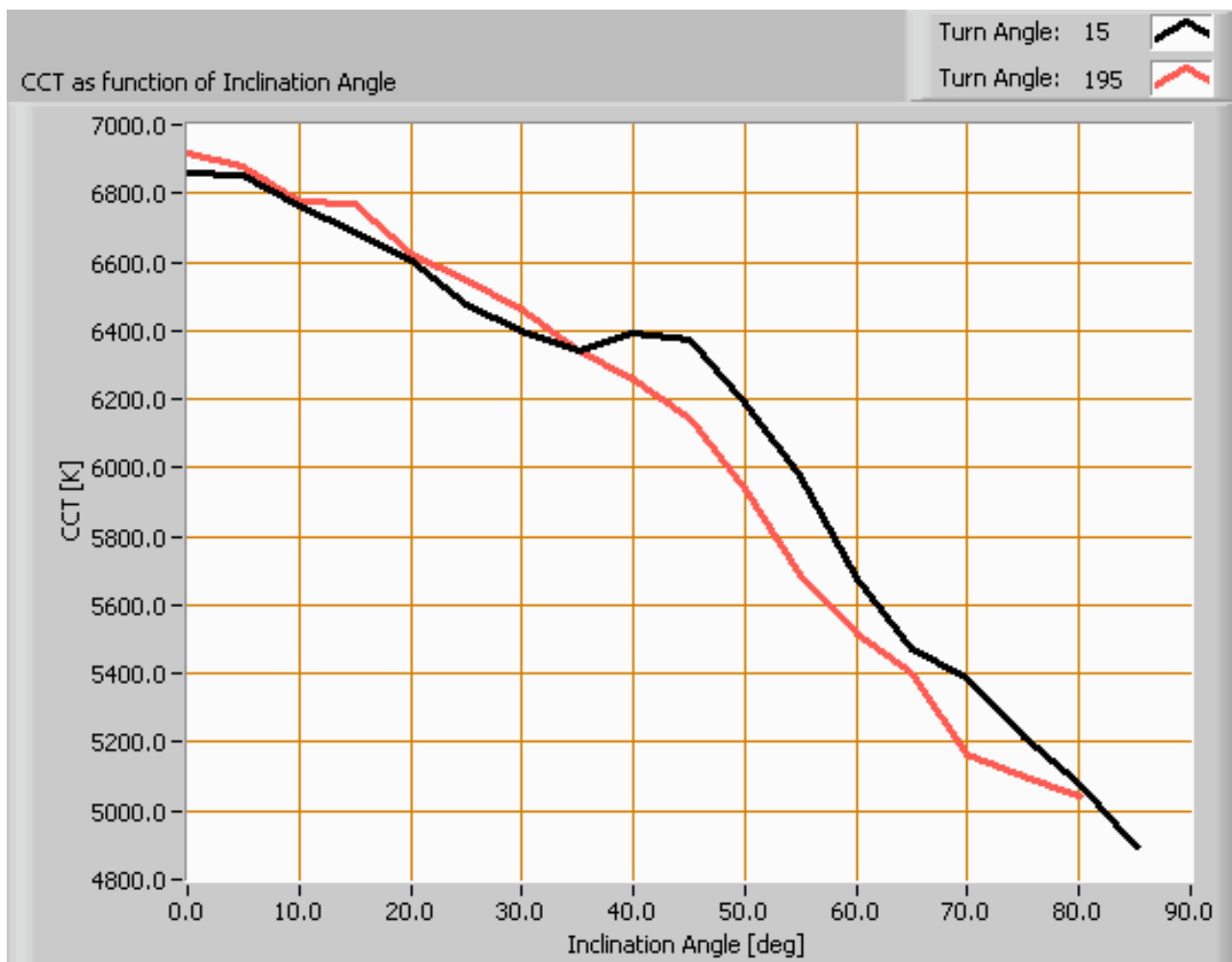


The spectral power distribution of this light bulb. Spectral energies on y-axis valid at 1 m.

The measured color temperature is about 6900 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 – 1 July 2009 for Leds Light The World BV



Color temperature as a function of inclination angle.

The color temperature is given for inclination angles up to 80 degrees; at higher inclination angles there is little illumination left.

The value slowly decreases. Within 40 degrees the variation stays within 8 %, up to 80 degrees inclination angle the decay is down to 73 % of the initial value.

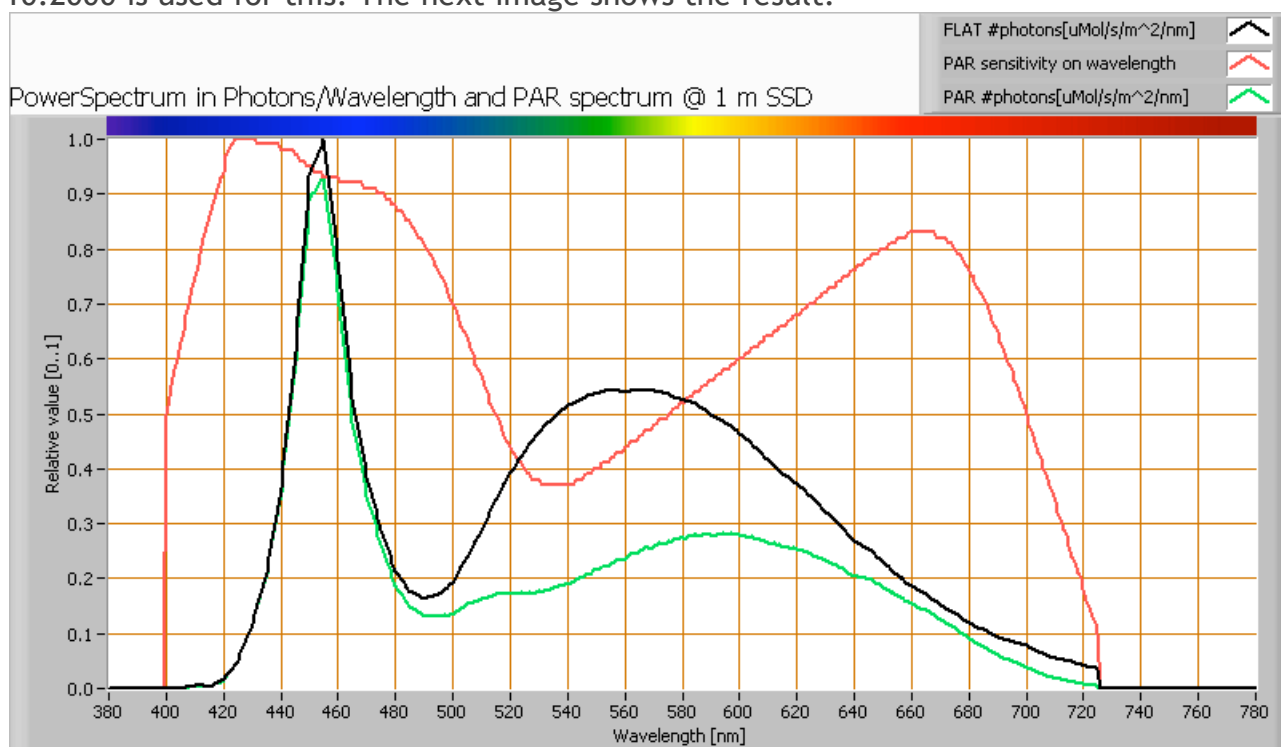
PAR value and PAR spectrum

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

Lamp measurement report – 1 July 2009 for Leds Light The World BV

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.



Lamp measurement report – 1 July 2009 for Leds Light The World BV

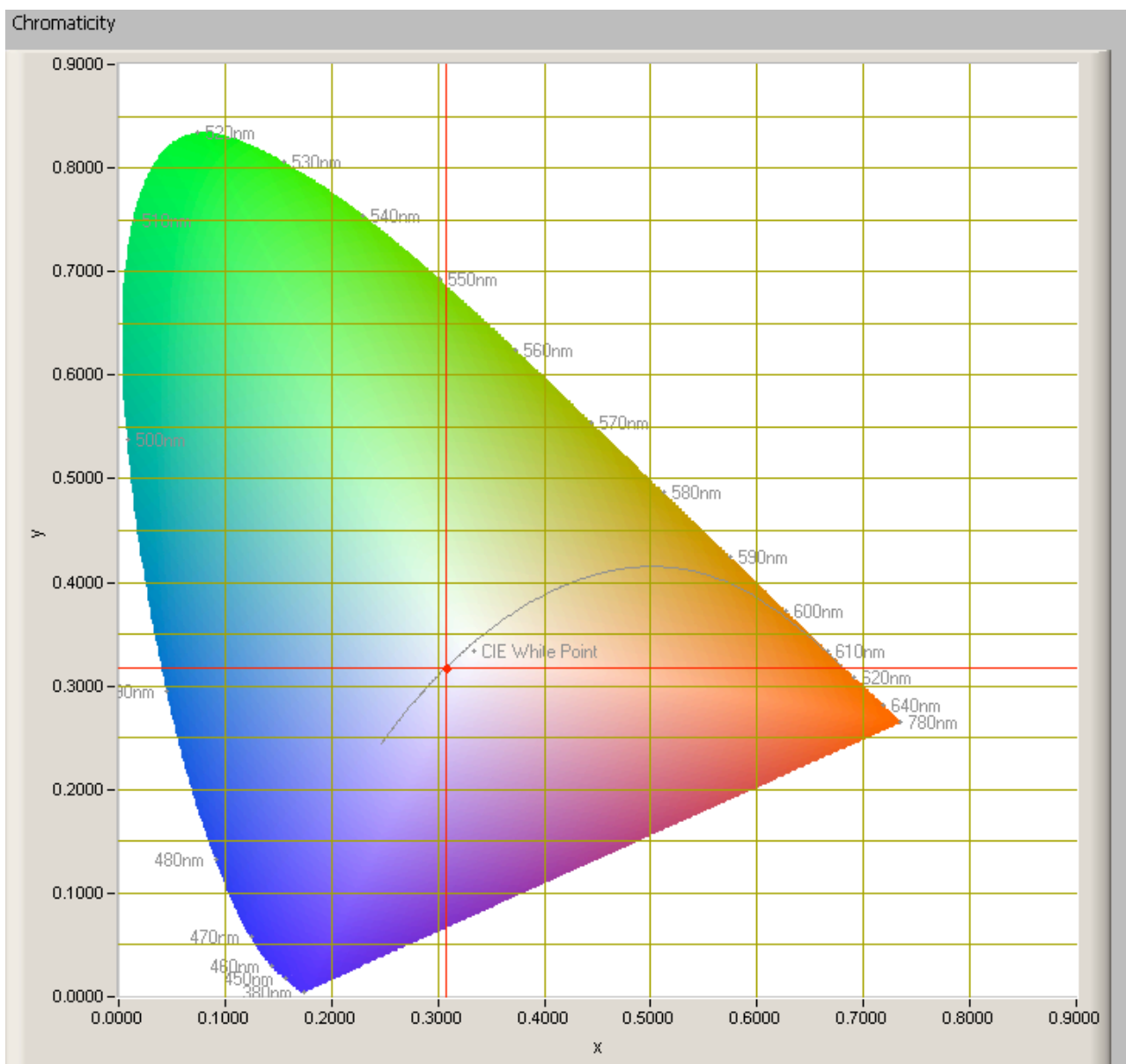
Summing all the photons, gives a PAR number that for this light results in $3.7 \mu\text{Mol/s/m}^2$. This value is valid at 1 m distance from this light bulb.

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 maximally 66 % of the photons is effectively used by the average plant (if the plant would be in such favorable environmental conditions that it absorbs all photons at the frequency where the 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.

Lamp measurement report – 1 July 2009 for Leds Light The World BV

Chromaticity diagram



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

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

Its coordinates are $x=0.3080$ and $y=0.3169$.

Lamp measurement report – 1 July 2009 for Leds Light The World BV

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: 6886 K

Chromaticity Difference DC= 3.9E-3

| | | |
|----------|-----------|---|
| R1= 77.8 | R8= 69.3 | Ra (mean value of R1 - R8) 78.7 |
| R2= 84.2 | R9= 2.8 | |
| R3= 83.6 | R10= 57.4 | |
| R4= 77.2 | R11= 72.6 | |
| R5= 76.7 | R12= 44.4 | |
| R6= 74.2 | R13= 79.8 | |
| R7= 87.1 | R14= 90.6 | |

CRI of the light of this lightbulb.

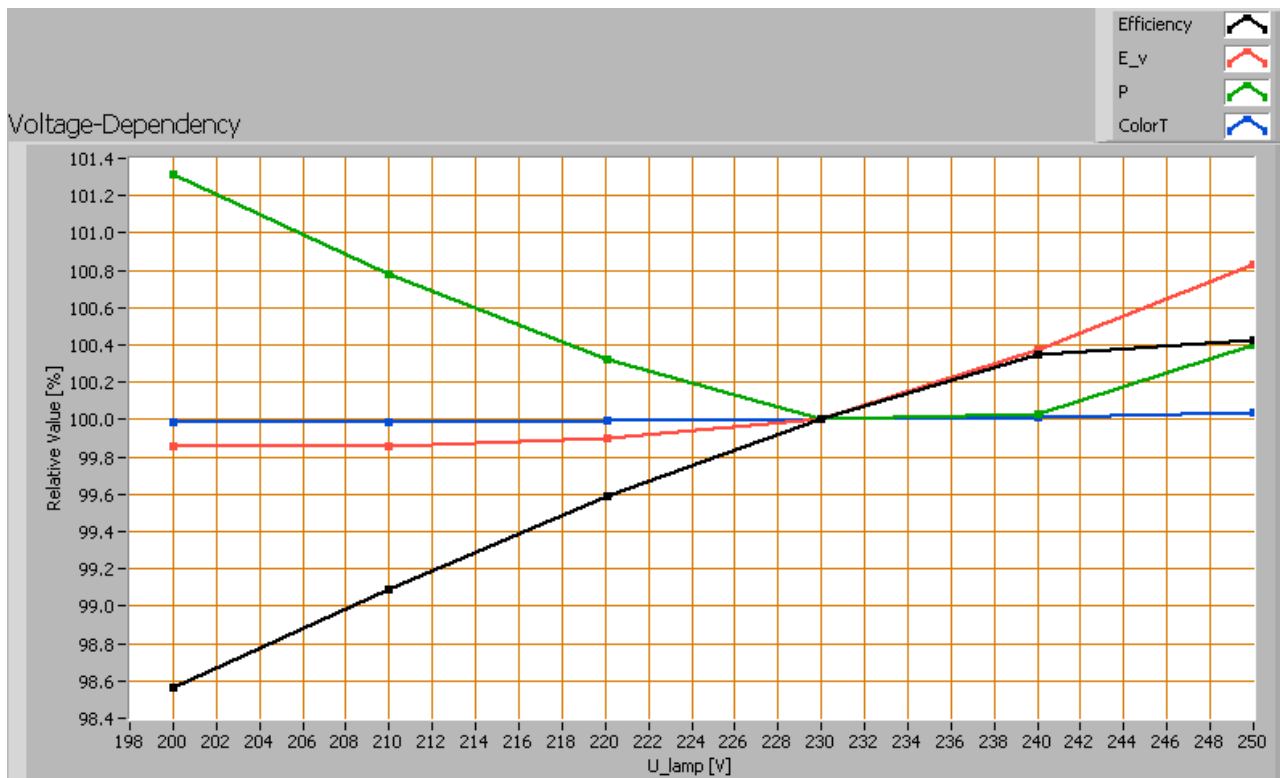
The value of 79 is (a bit) lower than 80 which is considered a minimum value for indoor usage.

Note: the chromaticity difference is 0.0039 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 lamp parameters measured: illuminance E_v [lx], the lamp power P [W], the (Correlated) Color Temperature [K] and the luminous efficacy [lm/W].

Lamp measurement report – 1 July 2009 for Leds Light The World BV



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

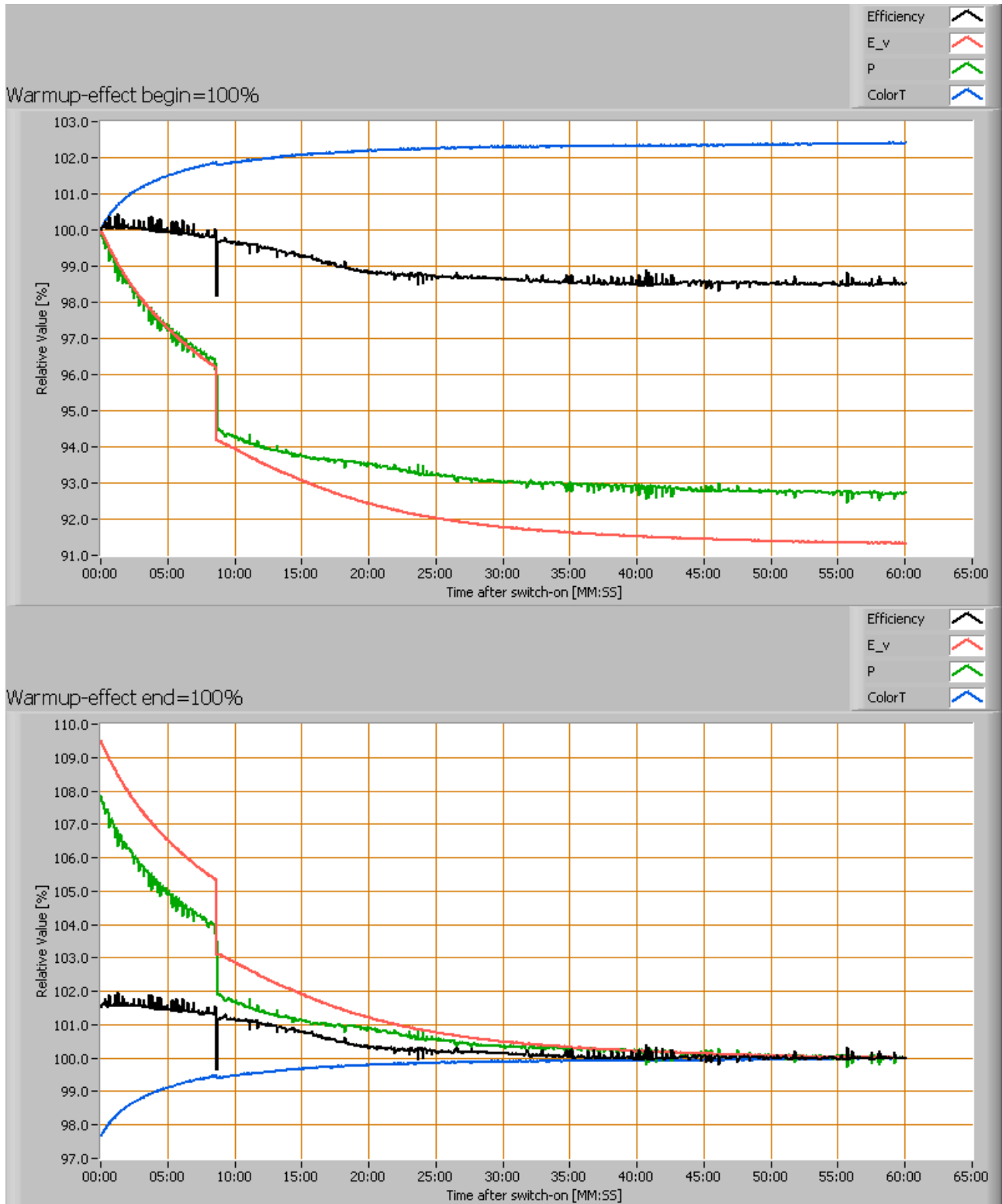
There is no significant variation of parameters when the voltage varies in the 200 - 250 V range.

When the voltage at 230 V varies with + and - 5 V abruptly, then the illuminance varies within 0.2 %, 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 lamp power P [W] and the luminous efficacy [lm/W].

Lamp measurement report – 1 July 2009 for Leds Light The World BV



Lamp measurement report – 1 July 2009 for Leds Light The World BV

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 takes 30 minutes and during that time the illuminance decreases with 10 % and the consumed power with 7 %.

Additional photo



A close up of the leds

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