

## Lamp measurement report - 18 Sep 2017

### Led Tube 7B

by

Lighthero GmbH



## Lamp measurement report - 18 Sep 2017

### Summary measurement data dated 2017-09-17

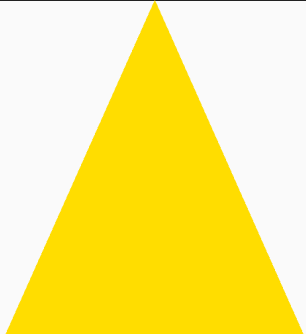
| parameter                         | meas. result              | remark  |
|-----------------------------------|---------------------------|---|
| Color temperature                 | 3638 K                    | warm/neutral white  |
| Luminous intensity I <sub>v</sub> | 761.1 Cd                  | Measured straight underneath the lamp.  |
| Illuminance modulation index      | 0 %                       | Measured with a light sensor looking at the lamp (angle not defined). Is a measure for the amount of flickering.                                    |
| Beam angle                        | 197 deg                   | 197 deg is the beam angle for all C-planes since the lamp is symmetrical along its 1st axis.  |
| Power P                           | 26.5 W                    | The net power consumed.   |
| Power Factor                      | 0.95                      | An electrical load with this power factor means that for every 1 kWh net energy consumed, there has been 0.33 kVAhr for reactive energy.            |
| THD                               | 21 %                      | Total Harmonic Distortion.  |
| Max inrush current                | 0.581 A                   | This current has been found at a voltage start angle of 80 degrees.   |
| Luminous flux                     | 4000 lm                   | Measured with photogoniometer, calculation done as described in LM79-08.  |
| Luminous efficacy                 | 151 lm/W                  |   |
| EU2013-label classification       | A++                       | The energy class, from A++ (more efficient) to E (least efficient). This label is an update of the previous version, and compulsory from Sept 2013. |
| CRI_Ra                            | 82                        | Color Rendering Index.  |
| Rf_TM30                           | 82                        | TM30-15 is an improved indicator (over CRI) of how well colors are rendered.  |
| Rg_TM30                           | 93                        | Gamut Area Ratio.   |
| Coordinates chromaticity diagram  | x=0.3915 en<br>y=0.3995   |   |
| Fitting                           | FL-tube                   | From one side to the grid voltage.  |
| PAR-value                         | 6.6 uMol/s/m <sup>2</sup> | 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               | 1.3 uMol/s/W <sub>e</sub> | The total emitted number of photons by this light, divided by its consumption in W. It indicates a kind of efficacy in generating photons.          |
| Photon current                    | 56.9 uMol/s               | The total number of photons in the light of this lamp.  |

## Lamp measurement report - 18 Sep 2017

| parameter                     | meas. result            | remark  |
|-------------------------------|-------------------------|---|
| 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 | 1495 mm x 28 mm x 28 mm | External dimensions of the lamp.  |
| L x W x H luminous area       | 1400 mm x 26 mm x 26 mm | Dimensions of the luminous area (used in Eulumdat file). It is the surface of the tube.   |
| General remarks               |                         | <p>The ambient temperature during the whole set of illuminance measurements was 25.1 - 25.2 deg C. The temperature of the lamp gets maximally about 38 degrees hotter than ambient temperature. Warm up effect: During the warmup time the illuminance varies during 15 minutes and decreases with 7 %.</p> <p>During the warmup time the power doesn't vary significantly (&lt; 5 %).</p> <p>The variation in efficacy (calculated as indication by simply dividing the illuminance by the power) during the warming up is -3 %.</p> <p>A very high negative value indicates a significant decrease for instance due to heating up of the lamp (decrease of lifetime). Voltage dependency: There is no (significant) dependency of the illuminance when the power voltage varies between 200 - 250 V AC.</p> <p>There is no (significant) dependency of the consumed power when the power voltage varies between 200 - 250 V AC.</p> <p>At the end of the article an additional photo.</p> |
| Eff-variation                 | -3 %                    | This is the variation in efficacy (calculated as indication by simply dividing the illuminance by the power) during the warming up. A very high negative value indicates a significant decrease for instance due to heating up of the lamp (decrease of lifetime).  |
| Dimmable                      | no                      | Info from manufacturer.   |
| Melanopic effect factor       | 0.520                   | According to norm DIN SPEC 5031-100:2015-08.  |
| Blue Light Hazard risk group  | 0                       | 0=exempt, 1=low, 2 = moderate, 3=high risk. Indication value only for straight underneath the lamp.   |
| form factor                   | tube                    |   |

## Lamp measurement report - 18 Sep 2017

### Overview table

| m.   | Ø 50%  |         | C0-180: 197°<br>C90-270: 105°   | E (lux) | Luminaire Efficacy     |
|------|--------|---------|---|---------|------------------------|
|      | C0-180 | C90-270 |   |         | 151 (lumen per Watt)   |
| 7    |        | 18.4    |  | 16      | Half-peak diam C0-180  |
| 10.5 |        | 27.6    |   | 7       | x diameter(m)          |
| 14   |        | 36.7    |   | 4       | Half-peak diam C90-270 |
| 17.5 |        | 45.9    |   | 2       | 18.37 x diameter(m)    |
| 21   |        | 55.1    |   | 2       | Illuminance            |
| 24.5 |        | 64.3    |   | 1       | 761 / distance² (lux)  |
| 28   |        | 73.5    |   | 1       | Total Output           |
|      |        |         |   |         | 4000 (lumen)           |

Please note that this overview table makes use of calculations, use this data with care as explained on the OliNo site.

## Lamp measurement report - 18 Sep 2017

### EU 2013 Energy label classification

Since Sept 2013 these labels will be needed.

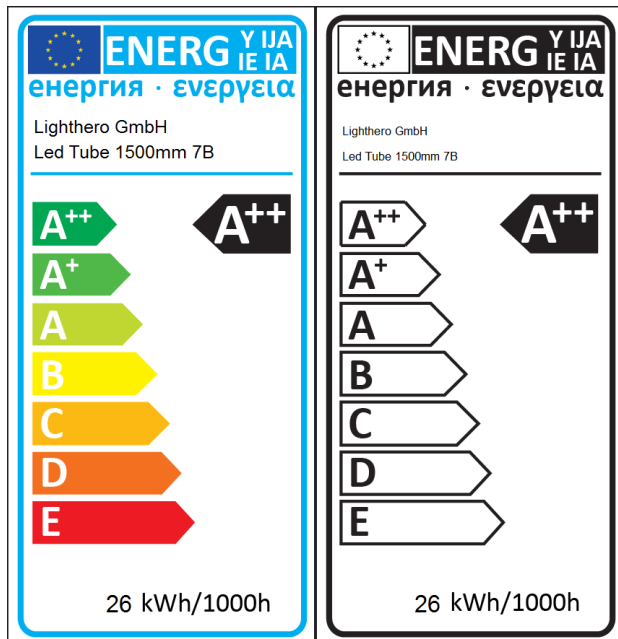
Important for the energy classification are the corrected rated power and the useful luminous flux.

The measured rated power is 26.5 W and might need to be corrected. The correction is dependent from the lamp type and whether or not the lamp control gear is included or not.

The choice for this lamp is the following classification: **Lamps with own control gear (external or internal)**. As a result the corrected rated power becomes: 26.5 W.

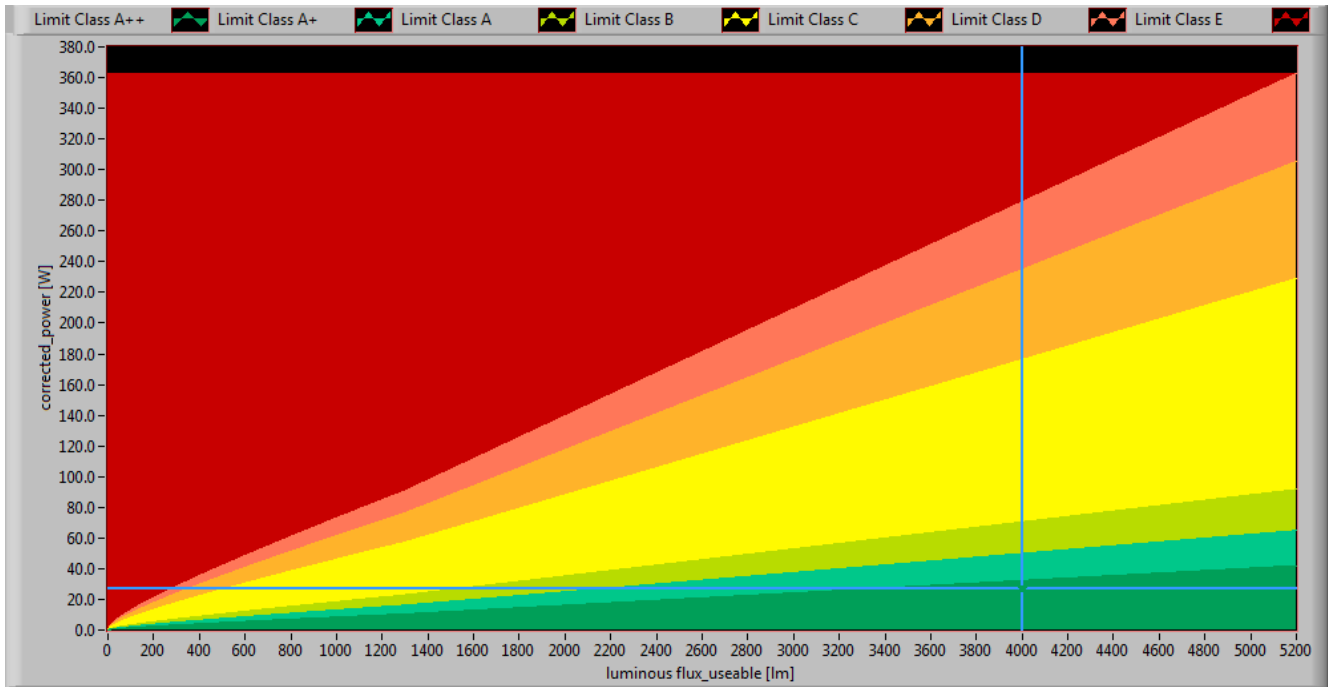
The luminous flux measured is 4000 lm. The classification of this lamp needed to determine the useful flux is: **Non-directional lamps**. Then the useful flux becomes 4000 lm. Now a reference power can be calculated.

The energy efficiency coefficient is  $P_{corr} / P_{ref} = 0.09$ .



EU energy label for this lamp

## Lamp measurement report - 18 Sep 2017

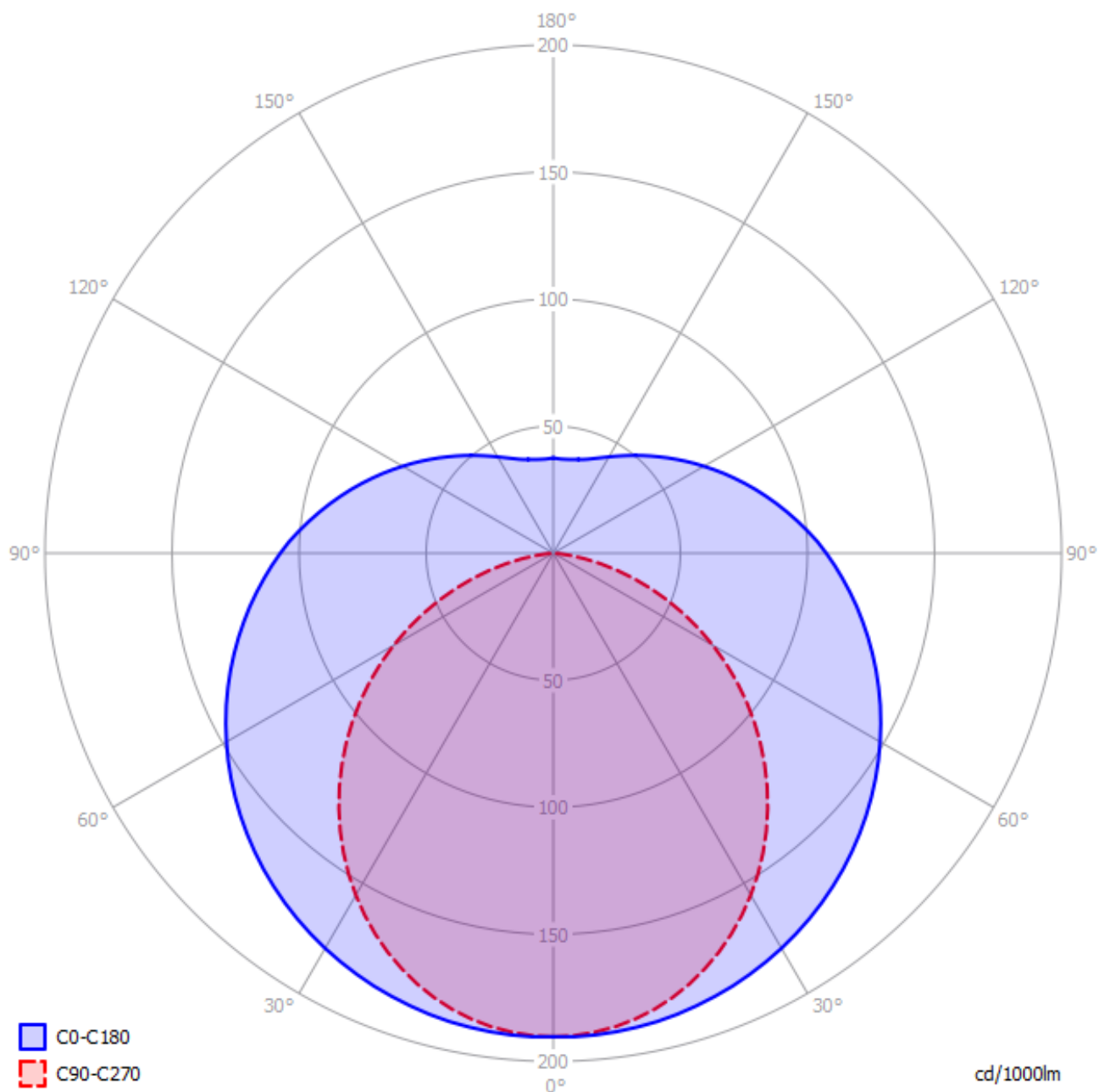


*The lamp's performance in the lumen-Watt field, with the energy efficacy fields indicated.*

## Lamp measurement report - 18 Sep 2017

### Eulumdat light diagram

This light diagram below comes from the program Qlumedit, that extracts these diagrams from an Eulumdat file.



*The light diagram giving the radiation pattern.*

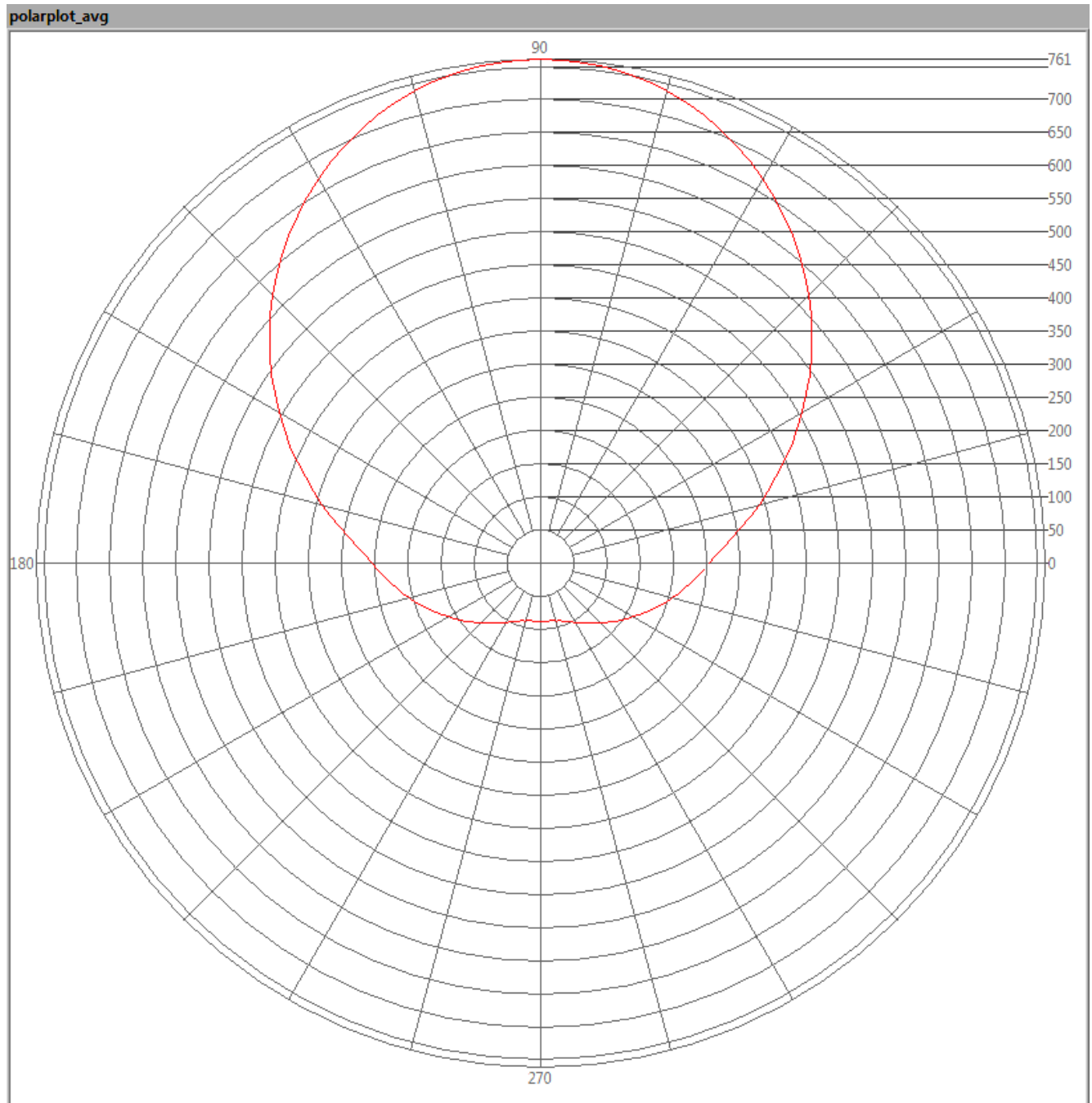
The light diagram indicates the beam in the C0-C180 plane and in the plane perpendicular to that, the C90-C270 plane. These beams are equal as the lamp has symmetry over its first axis (the vertical axis).



## Lamp measurement report - 18 Sep 2017

### 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.



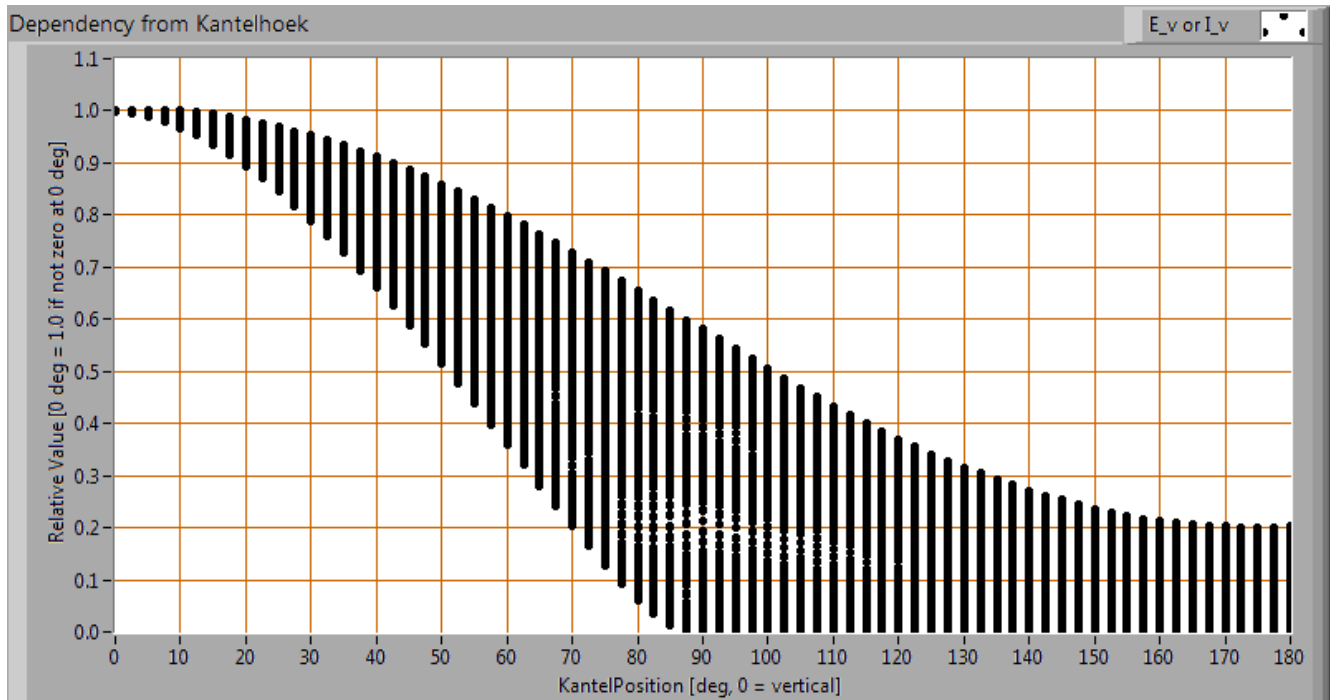
*The radiation pattern of the light bulb.*

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 - 18 Sep 2017



*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 197 deg for the C0-C180 plane and 105 deg for 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 4000 lm.

### Luminous efficacy

The luminous flux being 4000 lm, and the consumed power of the lamp being 26.5 Watt, results in a luminous efficacy of 151 lm/Watt.

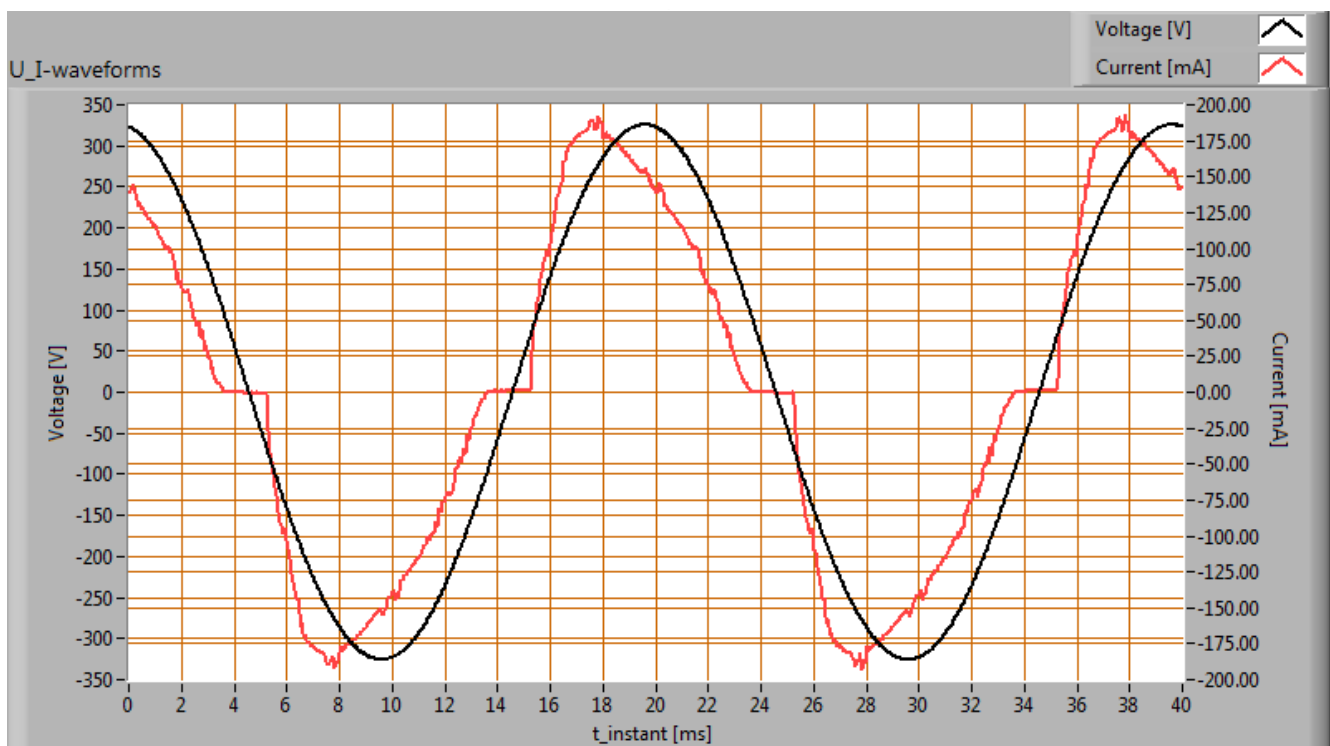
## Lamp measurement report - 18 Sep 2017

### Electrical properties

The power factor is 0.95. An electrical load with this power factor means that for every 1 kWh net energy consumed, there has been 0.33 kVAhr for reactive energy.

|                  |          |
|------------------|----------|
| Lamp voltage     | 230.16 V |
| Lamp current     | 0.121 A  |
| Power P          | 26.5 W   |
| Apparent power S | 27.9 VA  |
| Power factor     | 0.95     |

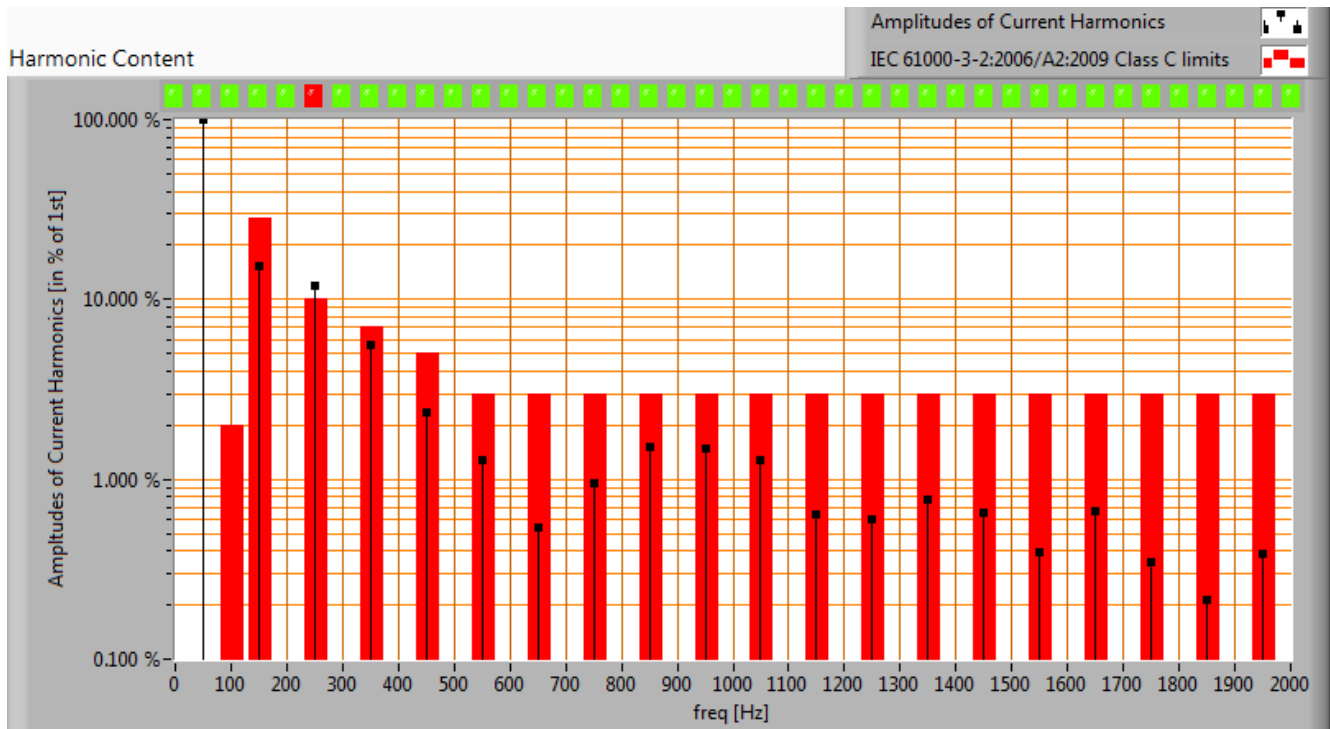
Of this lamp the voltage across and the resulting current through it are measured and graphed.



*Voltage across and current through the lightbulb*

This current waveform has been checked on requirements posed by the norm IEC 61000-3-2:2006 (including up to A2:2009).

## Lamp measurement report - 18 Sep 2017

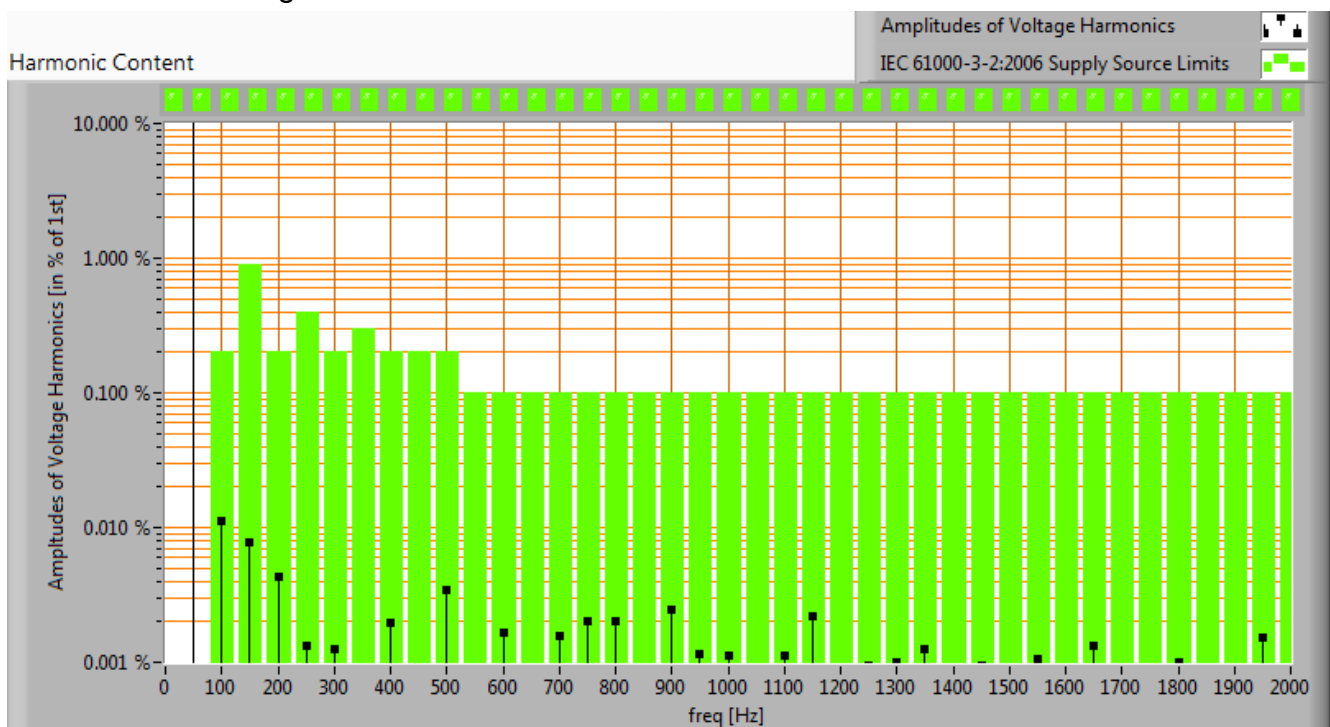


*Harmonics in the current waveform and checked against IEC61000-3-2:2006 and A2:2009*

When the consumed power is 25 W there are limits for the harmonics and those are not respected. See the note for additional explication.

The Total Harmonic Distortion of the current is computed and its value is 21 %.

Note: the used lampvoltage in this test is clean enough to be able to well evaluate the results of the current harmonics according to this norm. Herewith the image showing the harmonic content of the voltage used.



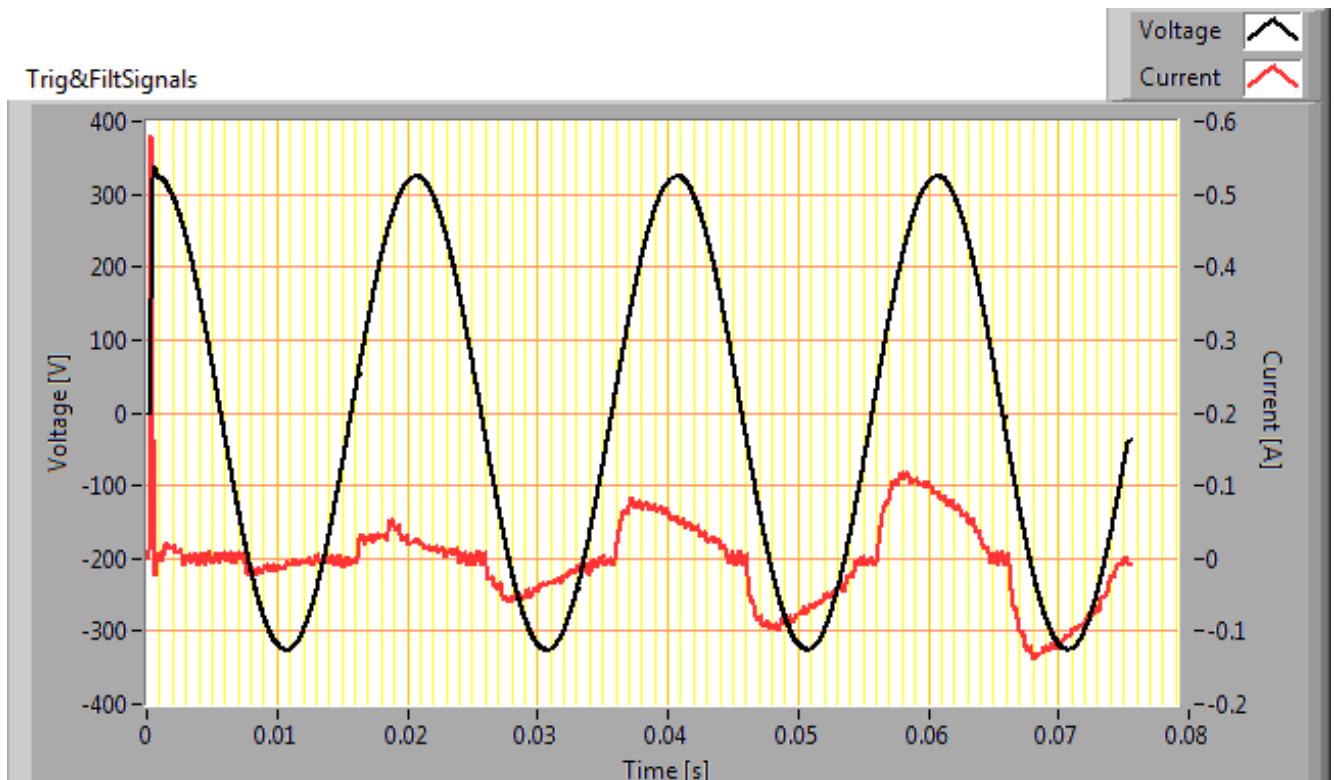
*Harmonics in the voltage waveform and checked against IEC61000-3-2:2006 and A2:2009.*

## Lamp measurement report - 18 Sep 2017

### Inrush current

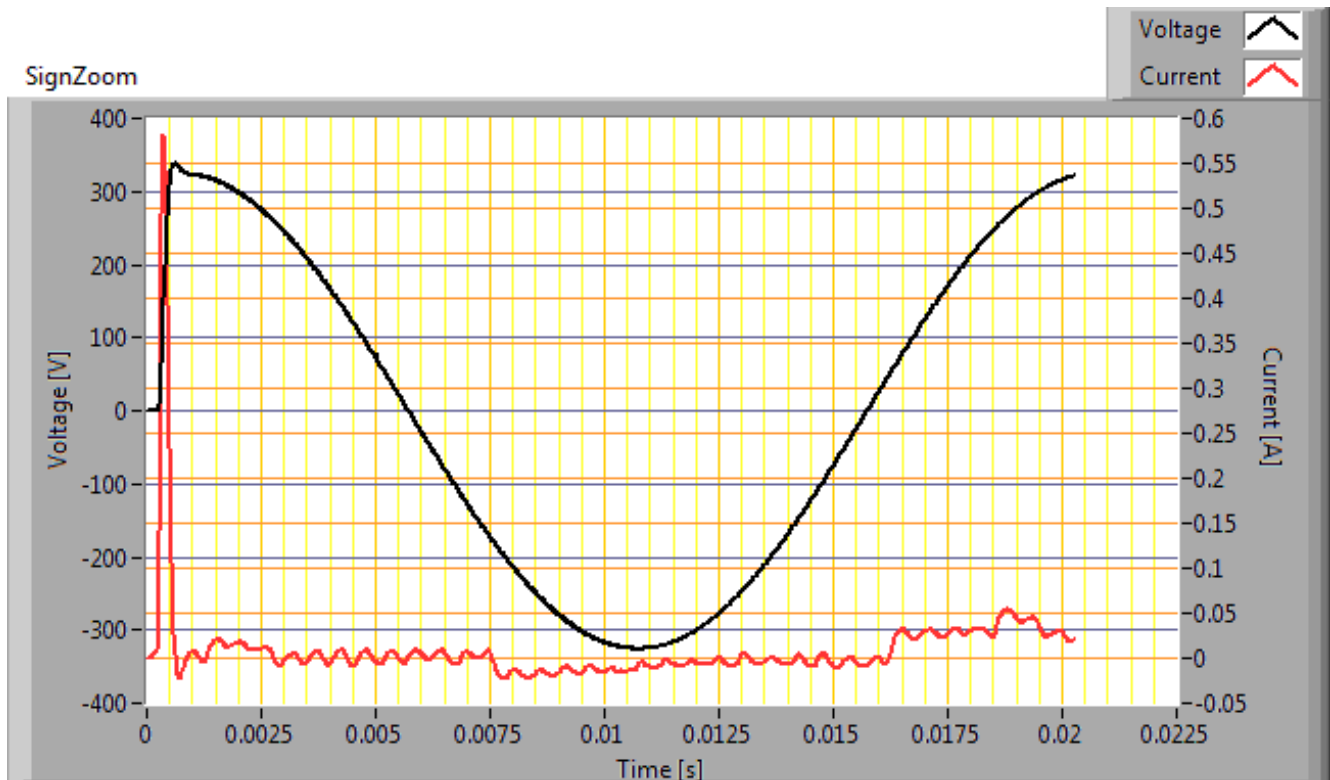
The inrush current has been measured for different voltage start angles; from 0 - 170 degrees with a 10 degrees step. The current- and voltage values have been acquired at a sample speed of 39.9 kS/s. Then this data has been fed into a second order 2kHz low pass Butterworth filter. This removes the current spikes that do not represent relevant values. The lamp was two minutes off before every inrush current measurement was made.

|   |            |  |
|---|------------|--|
| Test voltage  | 230.0 V    |  |
| Frequency of the voltage                                | 50.0 Hz    |  |
| Maximum inrush current                                  | 0.581 A    | This current has been found at a voltage start angle of 80 degrees.                                  |
| Pulse width of max inrush current                       | 3.3E-4 s   | This is the time that the pulse is higher than 10 % of the max inrush current.                       |
| Minimal inrush current                                  | 0.138 A    | This current has been found at a voltage start angle of 10 degrees.                                  |
| $I^2 \times t$ after 10 ms at 0 deg voltage start angle | 9.000E-6 A | This is the $I^2 t$ value when a zero crossing detector is used to start the voltage from 0 degrees. |

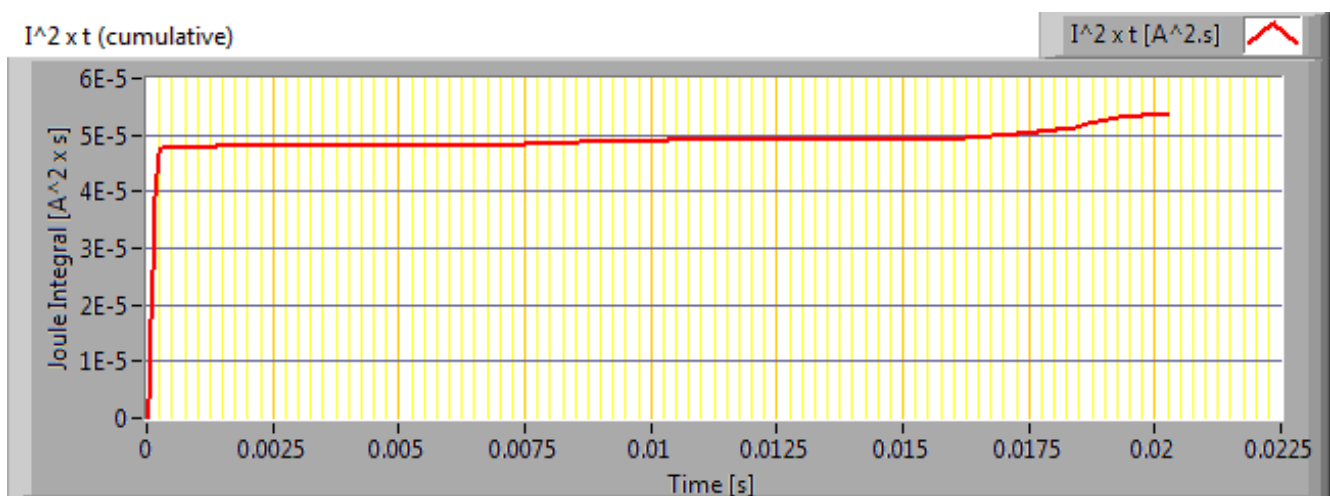


*Inrush current found at worst-case voltage start angle*

## Lamp measurement report - 18 Sep 2017



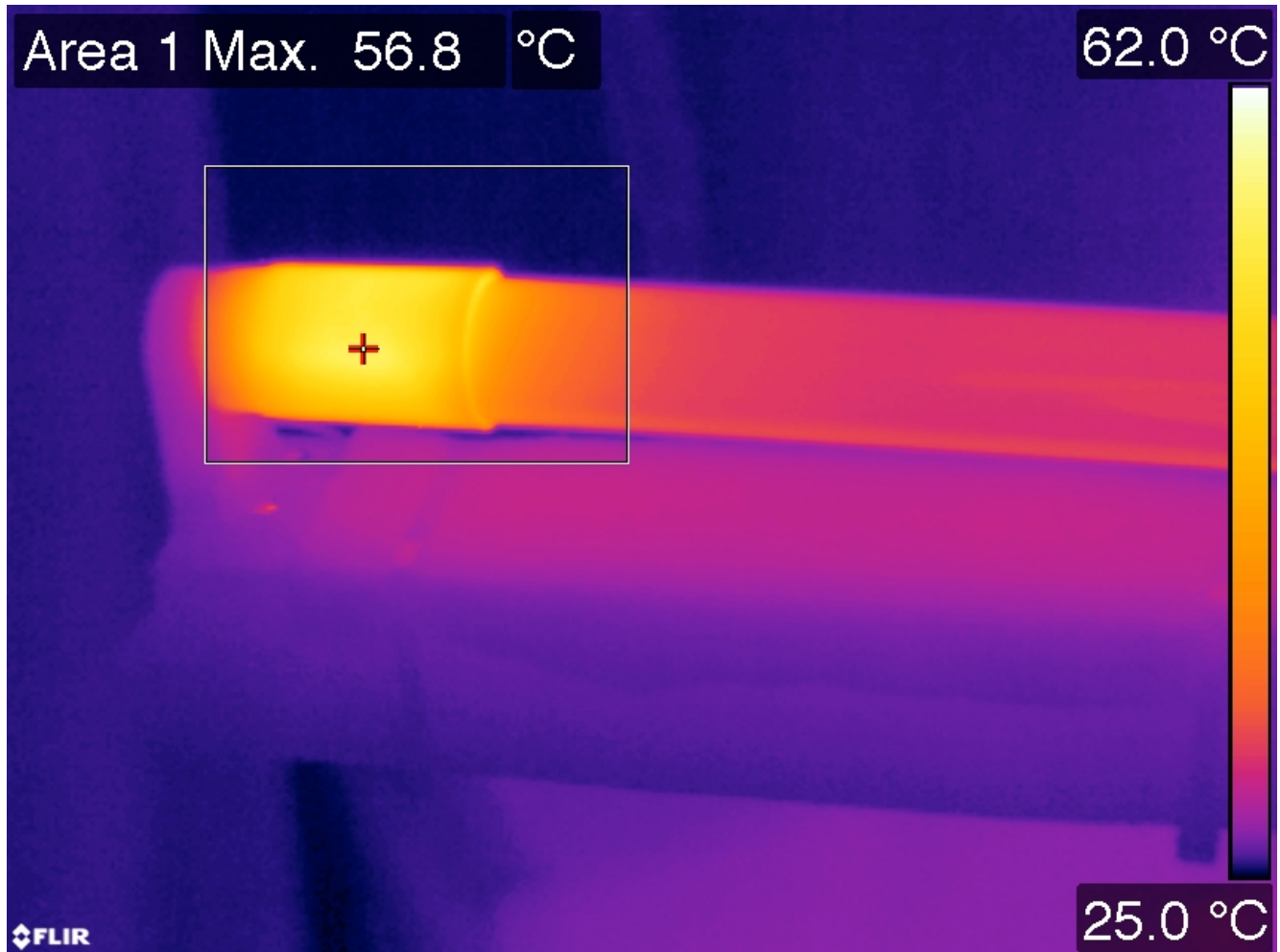
*First cycle of the maximum inrush current*



*The energy  $I^2t$  during the first 10 ms of the first current cycle*

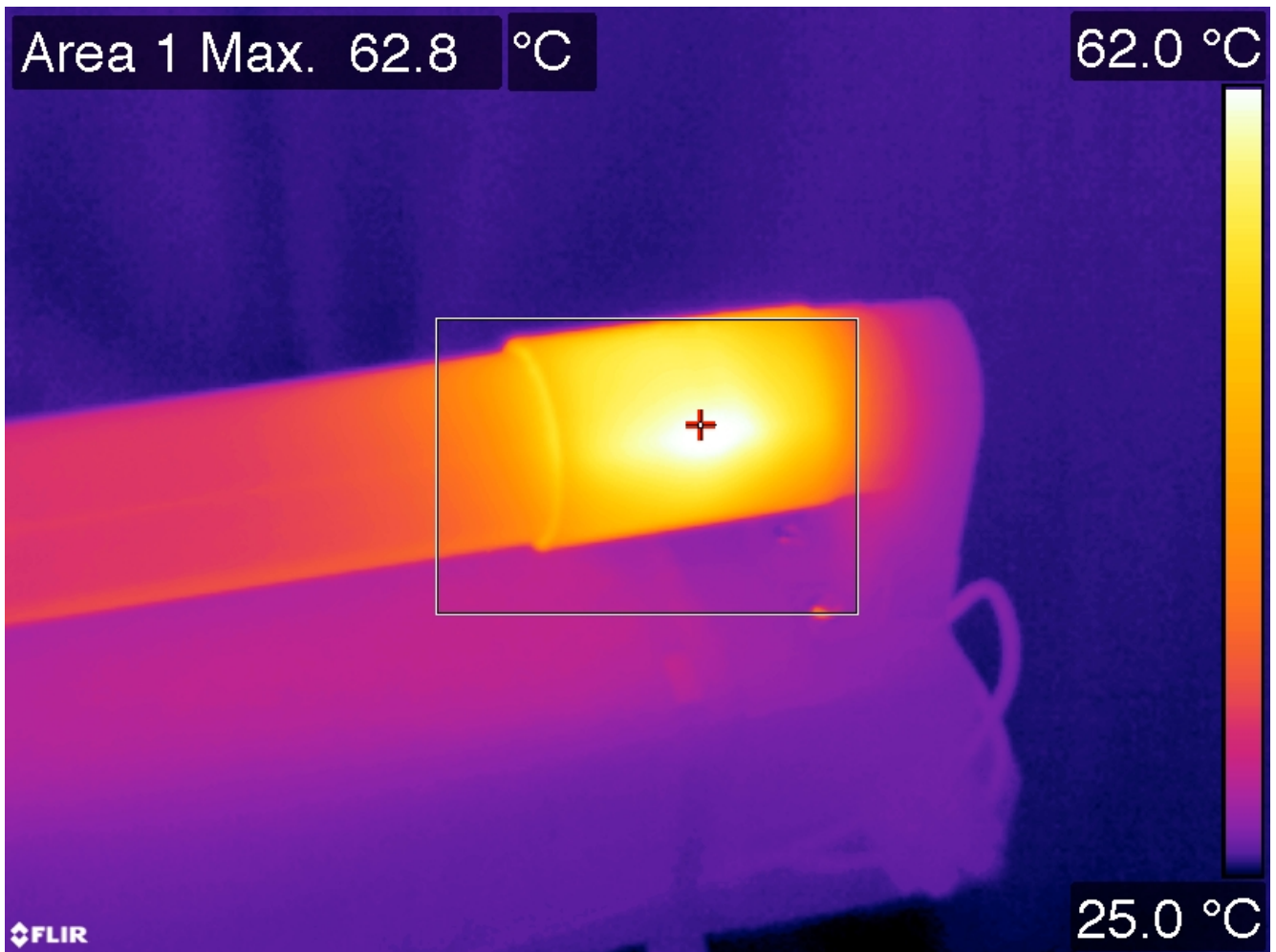
Lamp measurement report - 18 Sep 2017

Temperature measurements lamp



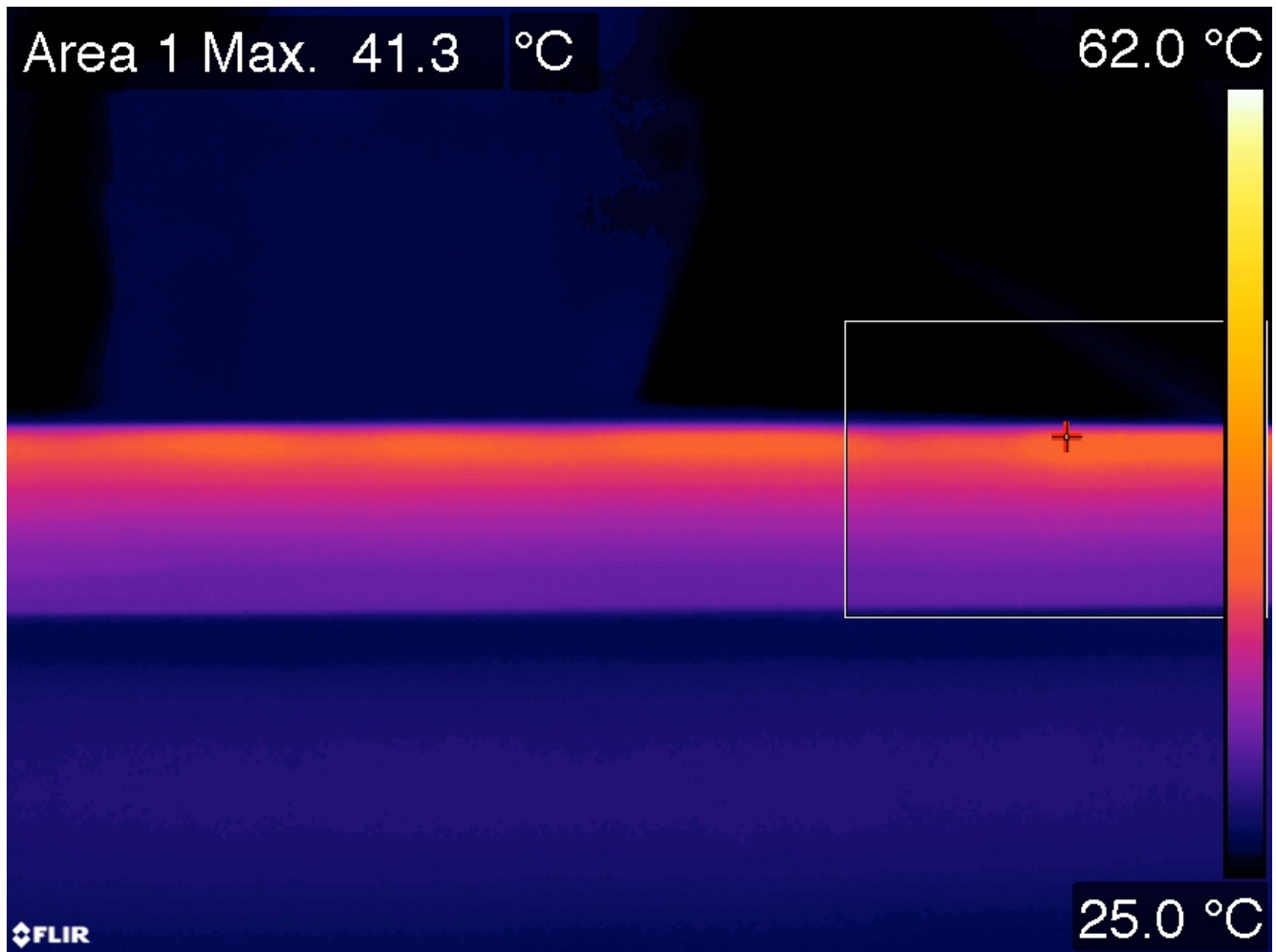


**Lamp measurement report - 18 Sep 2017**





## Lamp measurement report - 18 Sep 2017

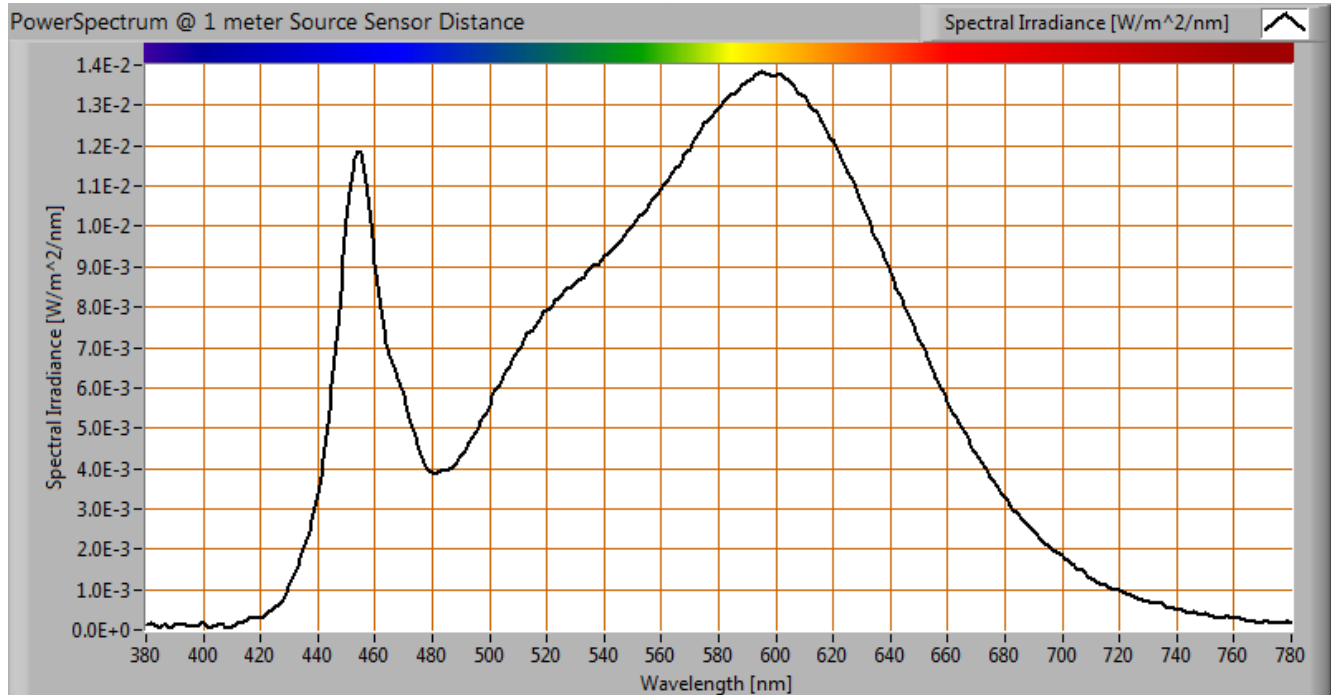


Temperature image(s).

|                                  |                             |
|----------------------------------|-----------------------------|
| status lamp                      | 2 hours on                  |
| ambient temperature              | 25 deg C                    |
| reflected background temperature | 25 deg C                    |
| camera                           | Flir T335                   |
| emissivity                       | 0.95                        |
| measurement distance             | 0.5 m                       |
| IFOV_geometric                   | 0.136 mm per 0.1 m distance |
| NETD (thermal sensitivity)       | 50 mK                       |

## Lamp measurement report - 18 Sep 2017

### Color temperature and Spectral power distribution

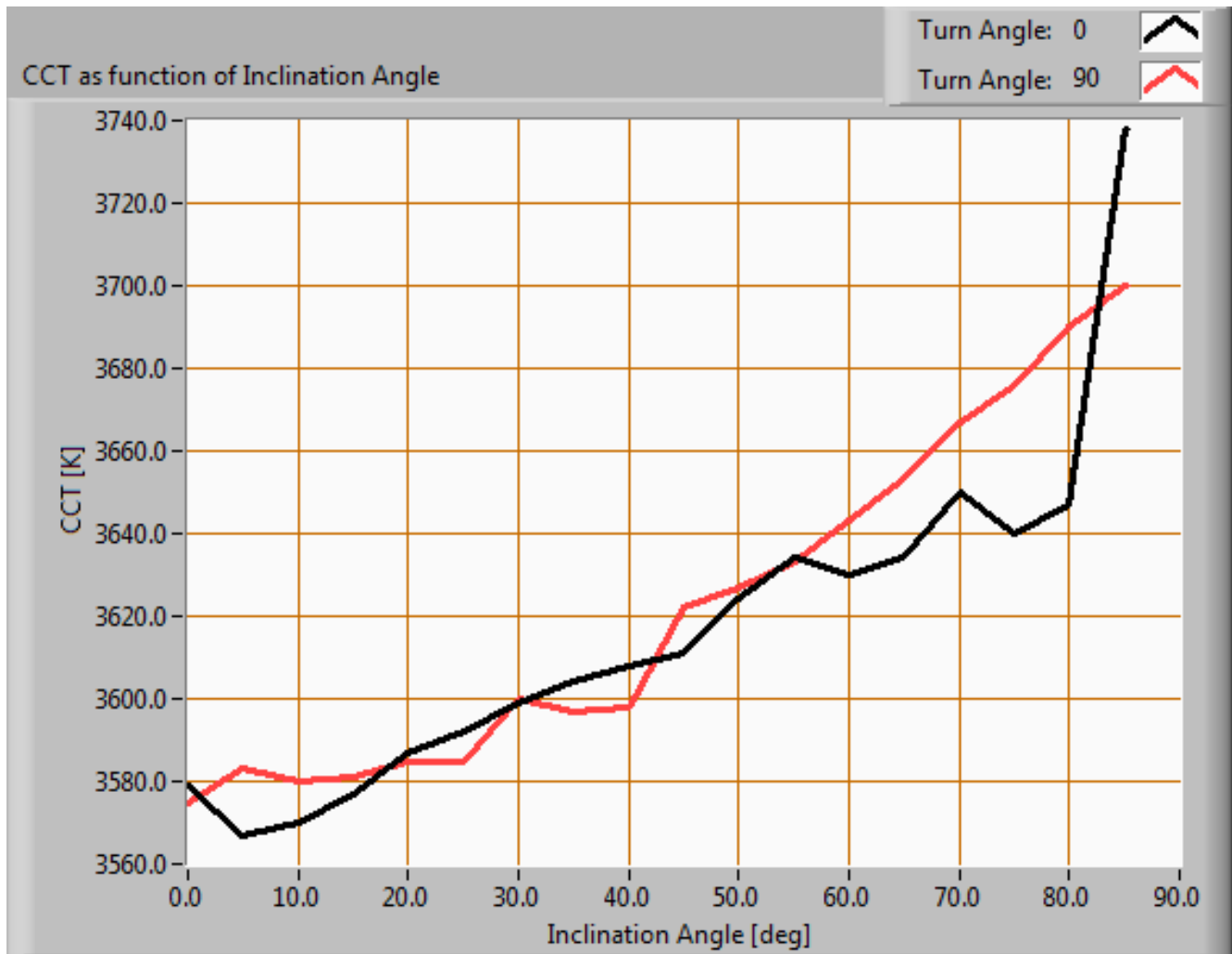


The spectral power distribution of this light bulb, energies on y-axis valid at 1 m distance.

The measured color temperature is 3638 K which is warm/neutral 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 - 18 Sep 2017



*Color temperature as a function of inclination angle.*

The color temperature is given for inclination angles up to 85 deg. Beyond that value the illuminance is so low ( 0.10 lux) that it has not been used for color determination of the light.

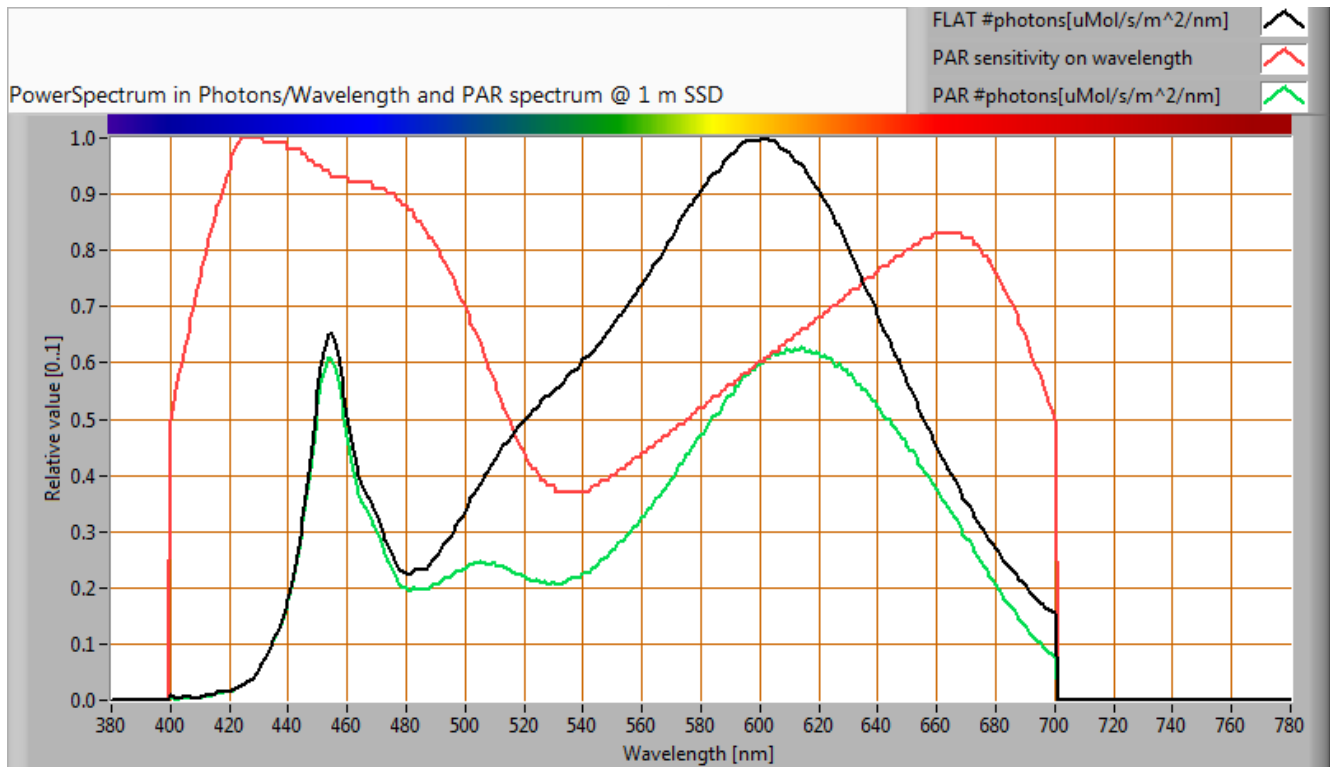
For the C0-C180 plane: the beam angle of 197 deg is equivalent to 98.7 deg inclination angle, which is the area where most of the light falls within. The maximum variation of color temperature in this inclination area is about 3 %.

For the C90-C270 plane: the beam angle of 105 deg is equivalent to 52.7 deg inclination angle, which is the area where most of the light falls within. The maximum variation of color temperature in this inclination area is about 1 %.

## Lamp measurement report - 18 Sep 2017

### 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.



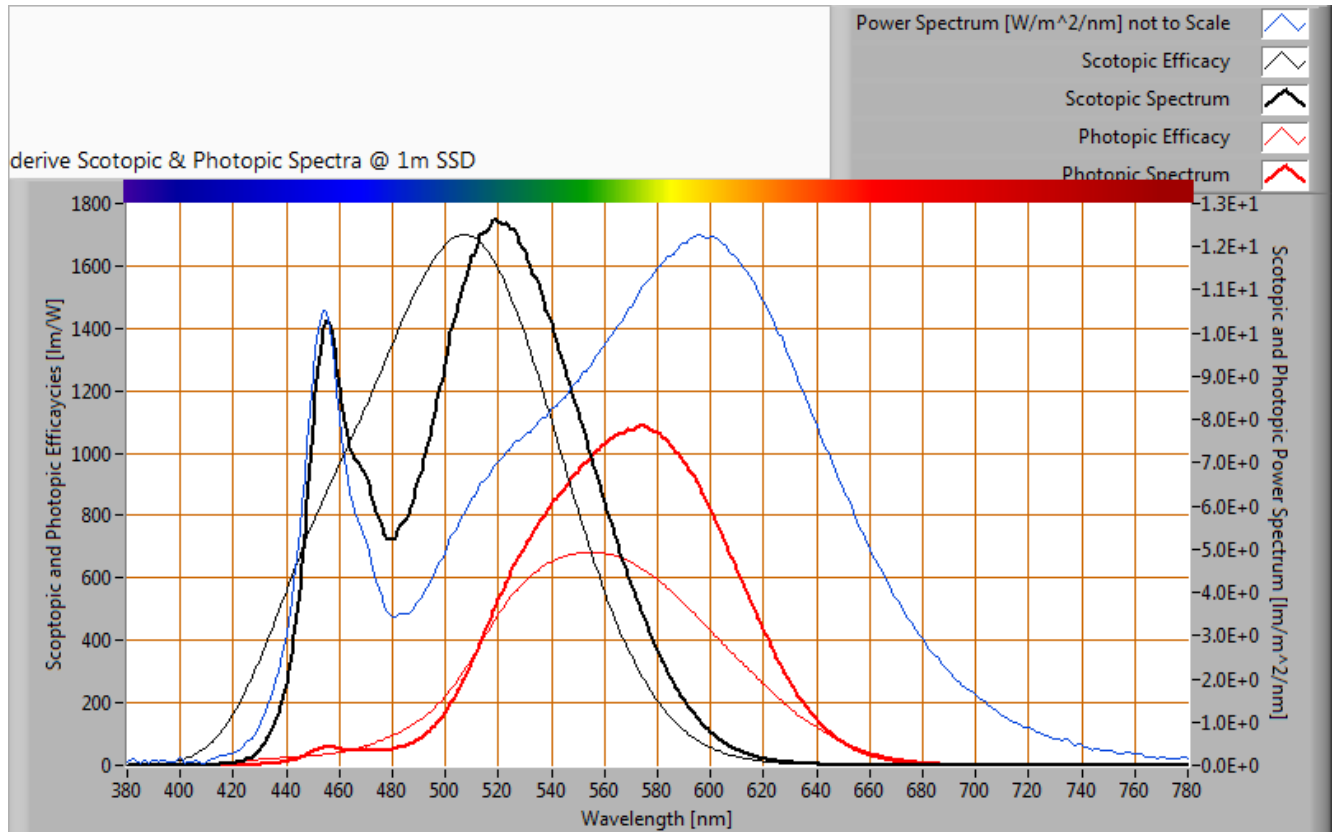
The photon spectrum, then the sensitivity curve and as result the final PAR spectrum of the light of this light bulb

| parameter           | value | unit                  |
|---------------------|-------|-----------------------|
| PAR number          | 6.6   | uMol/s/m <sup>2</sup> |
| PAR photon current  | 34.6  | uMol/s                |
| PAR photon efficacy | 1.3   | uMol/s/W              |

The PAR efficiency is 64 % (valid for the PAR wave length range of 400 - 700 nm). This is the maximum percentage of the total of photons in the light that 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 %).

## Lamp measurement report - 18 Sep 2017

### S/P ratio

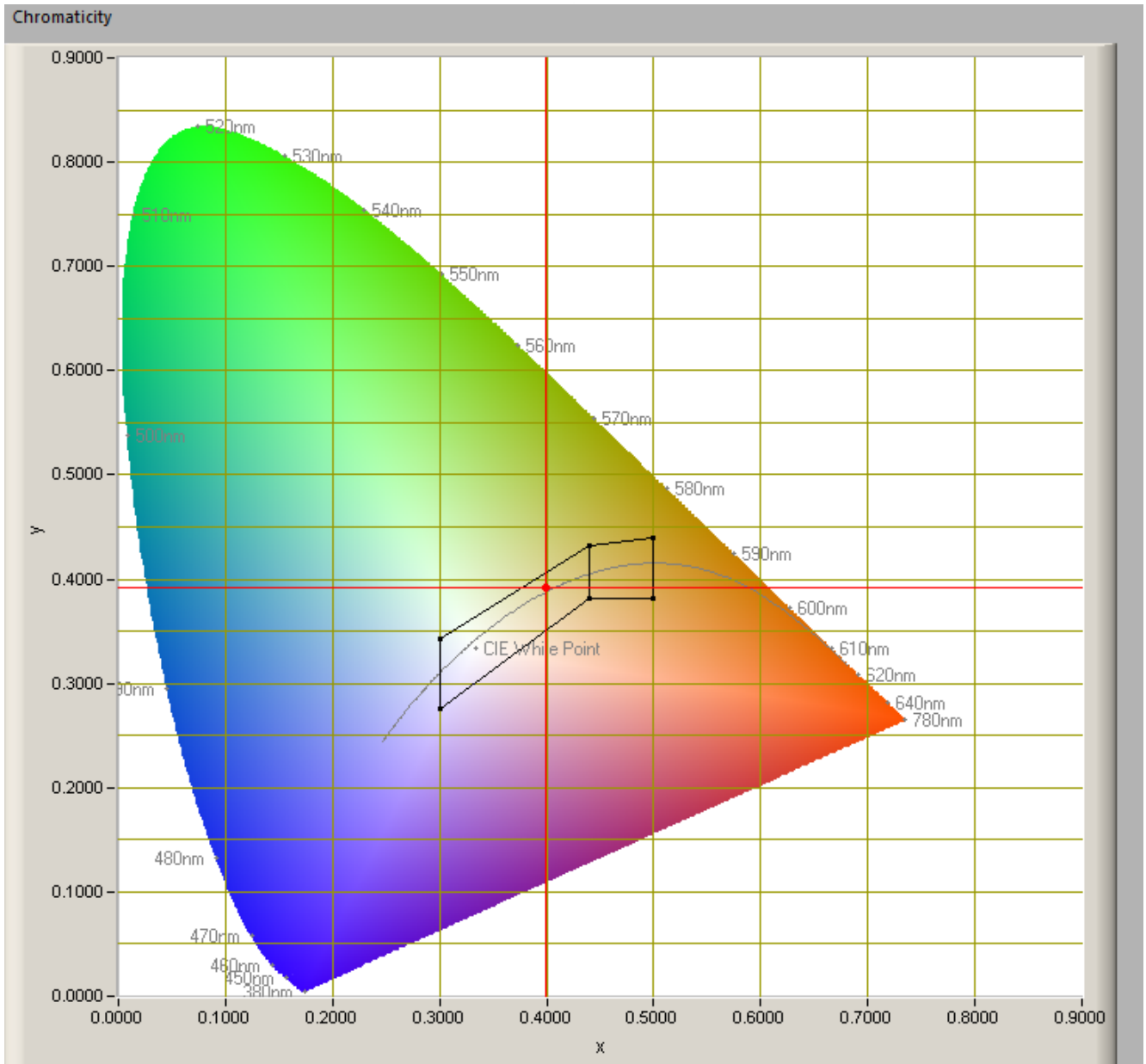


The power spectrum, sensitivity curves and resulting scotopic and photopic spectra (spectra energy content defined at 1 m distance).

The S/P ratio of the light coming from this lamp is 1.6.

## Lamp measurement report - 18 Sep 2017

### Chromaticity diagram



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

The point of the light in this diagram is inside the area indicated with class A. This area indicates an area for signal lamps.

The color coordinates are  $x=0.3915$  and  $y=0.3995$ .

## Lamp measurement report - 18 Sep 2017

### 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 CCT: 3638 K

Chromaticity Difference DC= 1.7E-3

|          |           |                         |
|----------|-----------|-------------------------|
| R1= 80.5 | R8= 60.8  | R15= 73.3               |
| R2= 90.5 | R9= 4.1   |                         |
| R3= 96.3 | R10= 77.4 | Ra                      |
| R4= 79.6 | R11= 78.2 | (mean value of R1 - R8) |
| R5= 80.4 | R12= 62.2 | <span>82.4</span>       |
| R6= 87   | R13= 83.2 |                         |
| R7= 84.2 | R14= 98.5 |                         |

*CRI of the light of this lightbulb.*

This value of 82 indicates how well the light of this lamp can render well a set of reference colors, this in comparison with the light of a reference source (for color temperatures 5000K a black radiator is used as reference and for color temperatures 5000K the sun or the light outside during the day).

The value of 82 is bigger than the value of 80 that is considered as a minimum for working areas in general.

Note: the chromaticity difference is 0.0017 and indicates the distance to the Planckian Locus. There is a value mentioned of max 5.4E-3 in section 5.3 of CIE 13.3-1995 however no further explanation of it.

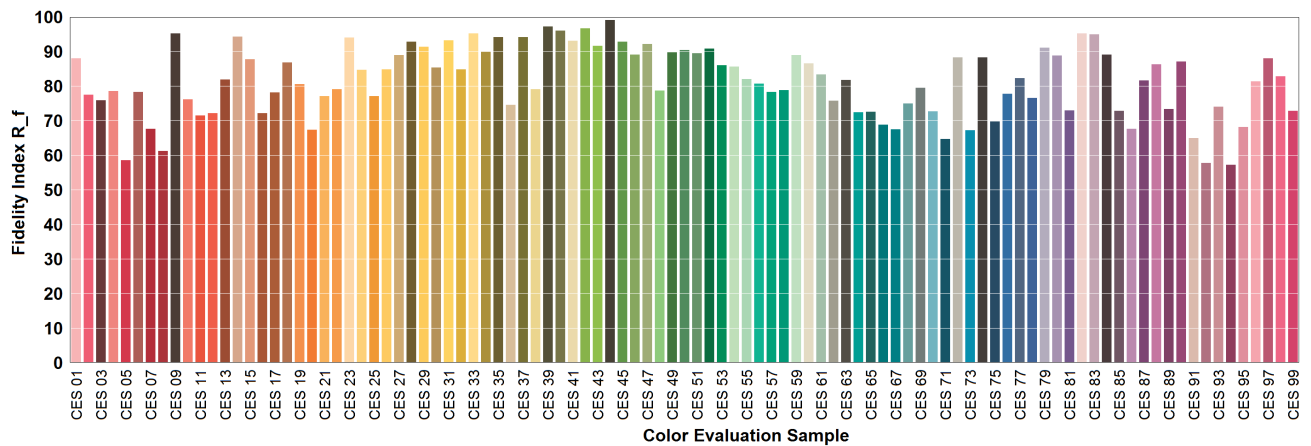
An other reference with signal lights as a reference is given in the chromaticity diagram.



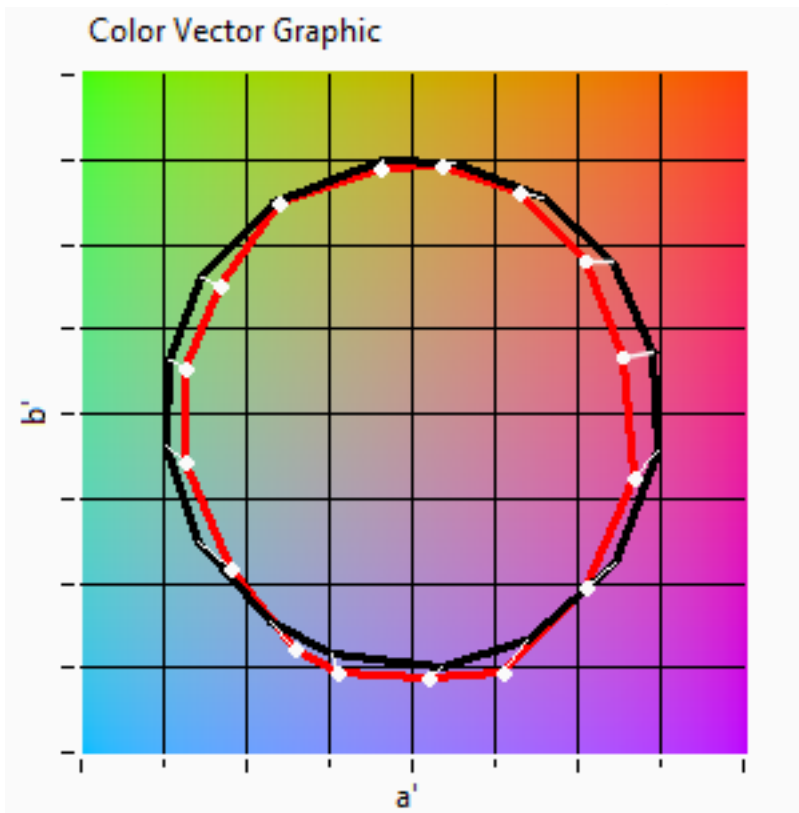
## Lamp measurement report - 18 Sep 2017

### Color quality scale TM-30-15

TM-30-15 is an improved indicator (over CRI) of how well colors are rendered.  
TM30-15 R<sub>f</sub> = 82, R<sub>g</sub> = 93.



TM-30-15-values for 99 samples for the light of this light bulb. The closer the value for a testcolor comes to 100, the more its rendition resembles that of a reference lightsource.

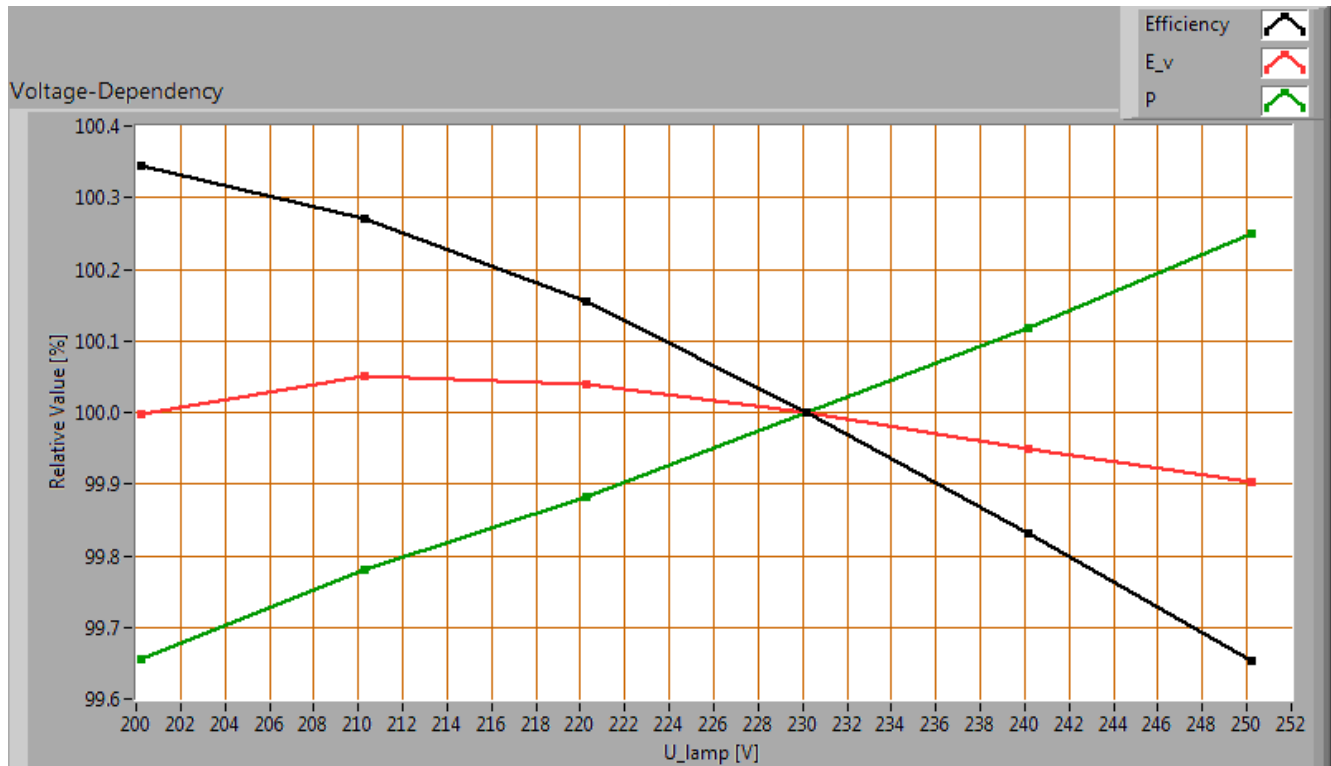


Graphical view of averaged color points for this light bulb compared to a reference source with the same color temperature.

## Lamp measurement report - 18 Sep 2017

### 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 lamp power  $P$  [W] and the luminous efficacy [lm/W] (this latter is estimated here by dividing the found  $E_v$  value by  $P$ ).



*Lamp voltage dependencies of certain light bulb parameters*

There is no (significant) dependency of the illuminance when the power voltage varies between 200 - 250 V AC.

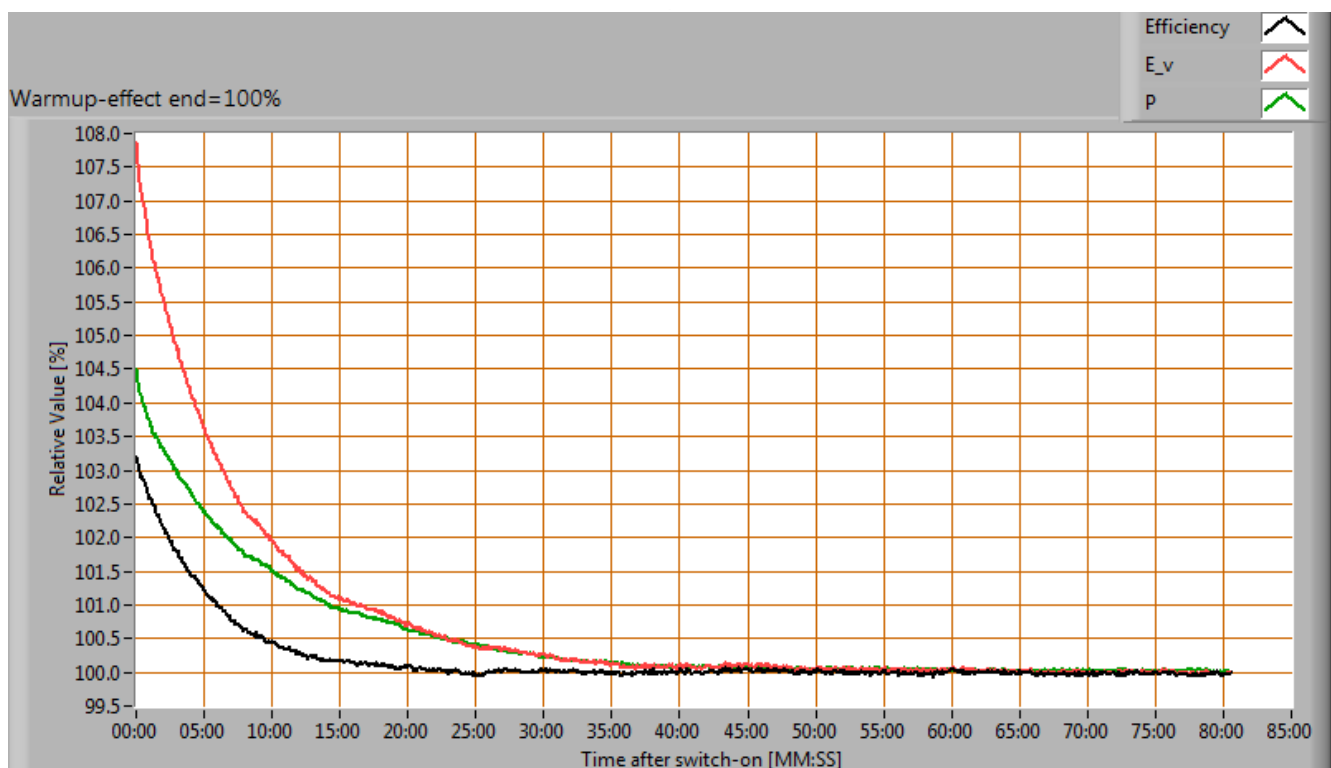
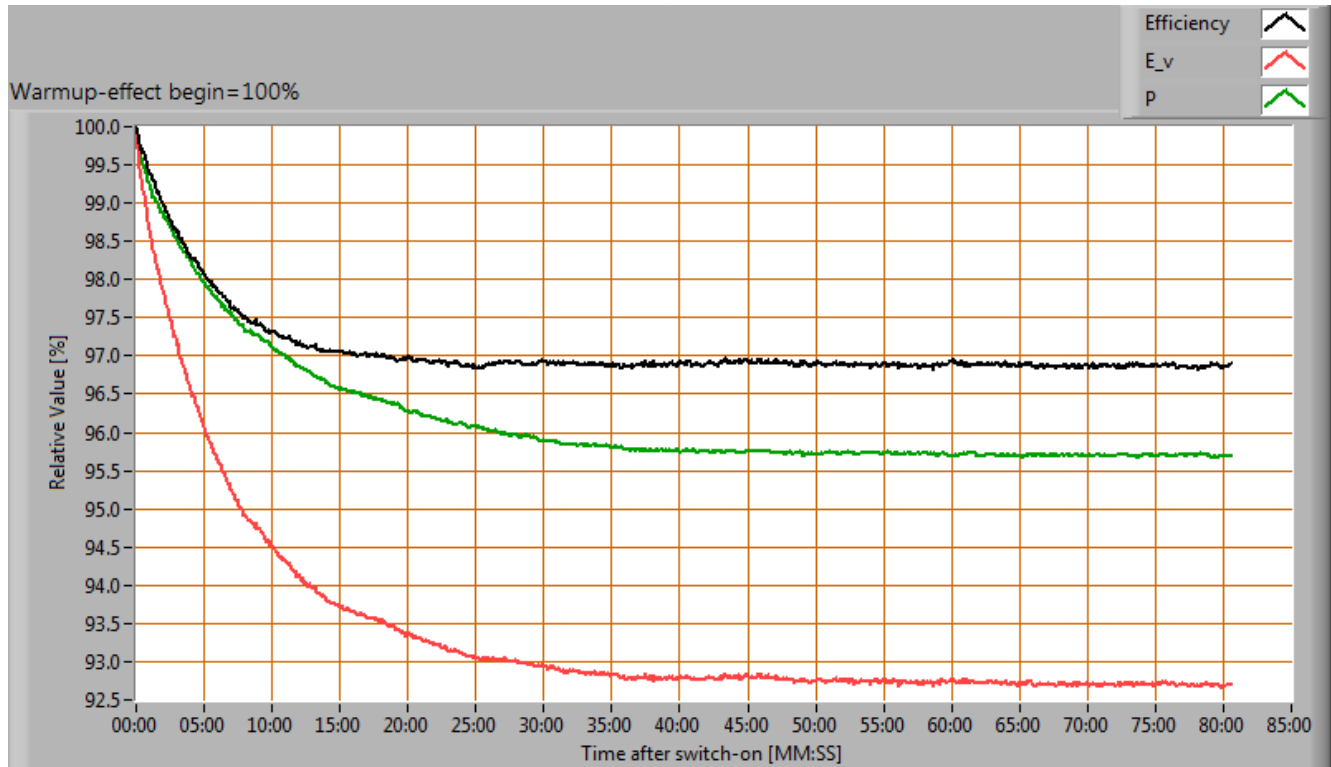
There is no (significant) dependency of the consumed power when the power voltage varies between 200 - 250 V AC.

When the voltage varies abruptly with + or - 5 V AC then this results in a variation of the illuminance of maximally 0.0 %. This difference in illuminance is not visible (when it occurs abruptly).

## Lamp measurement report - 18 Sep 2017

### 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].



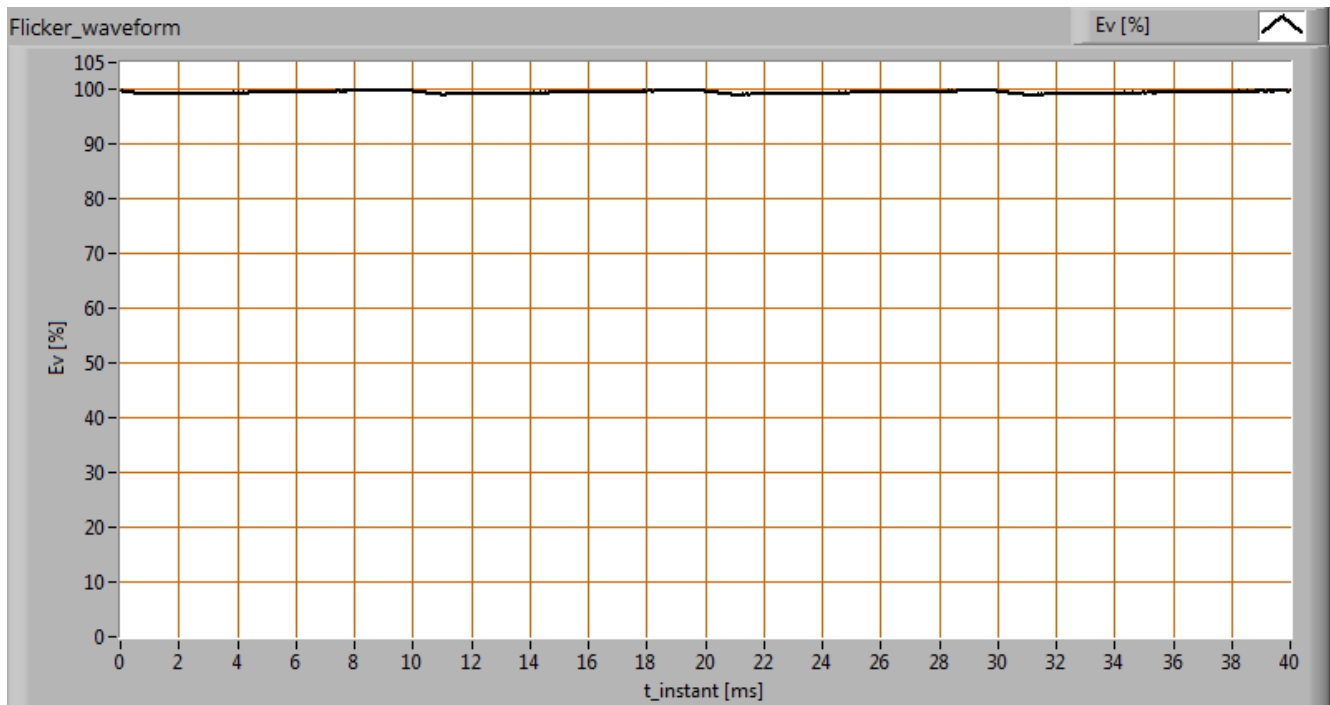
Effect of warming up on different light bulb parameters. In the first graph the 100 % level is put at begin, and in the last graph the 100 % level is put at the end.

## Lamp measurement report - 18 Sep 2017

During the warmup time the illuminance varies during 15 minutes and decreases with 7 %. During the warmup time the power doesn't vary significantly ( 5 %). The variation in efficacy (calculated as indication by simply dividing the illuminance by the power) during the warming up is -3 %. A very high negative value indicates a significant decrease for instance due to heating up of the lamp (decrease of lifetime).

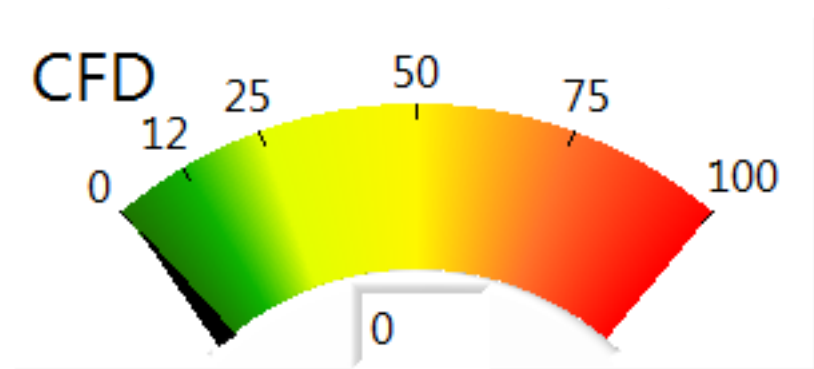
### Measure of flickering

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                    | value | unit |
|------------------------------|-------|------|
| Flicker frequency            | 99.9  | Hz   |
| Illuminance modulation index | 0     | %    |
| Flicker index                | 0.001 | [-]  |
| Compact Flicker Degree       | 0     | %    |



Flicker free.

The illuminance modulation index is computed as:  $(\max\_Ev - \min\_Ev) / (\max\_Ev + \min\_Ev)$ .

## Lamp measurement report - 18 Sep 2017

### Melanopic effect

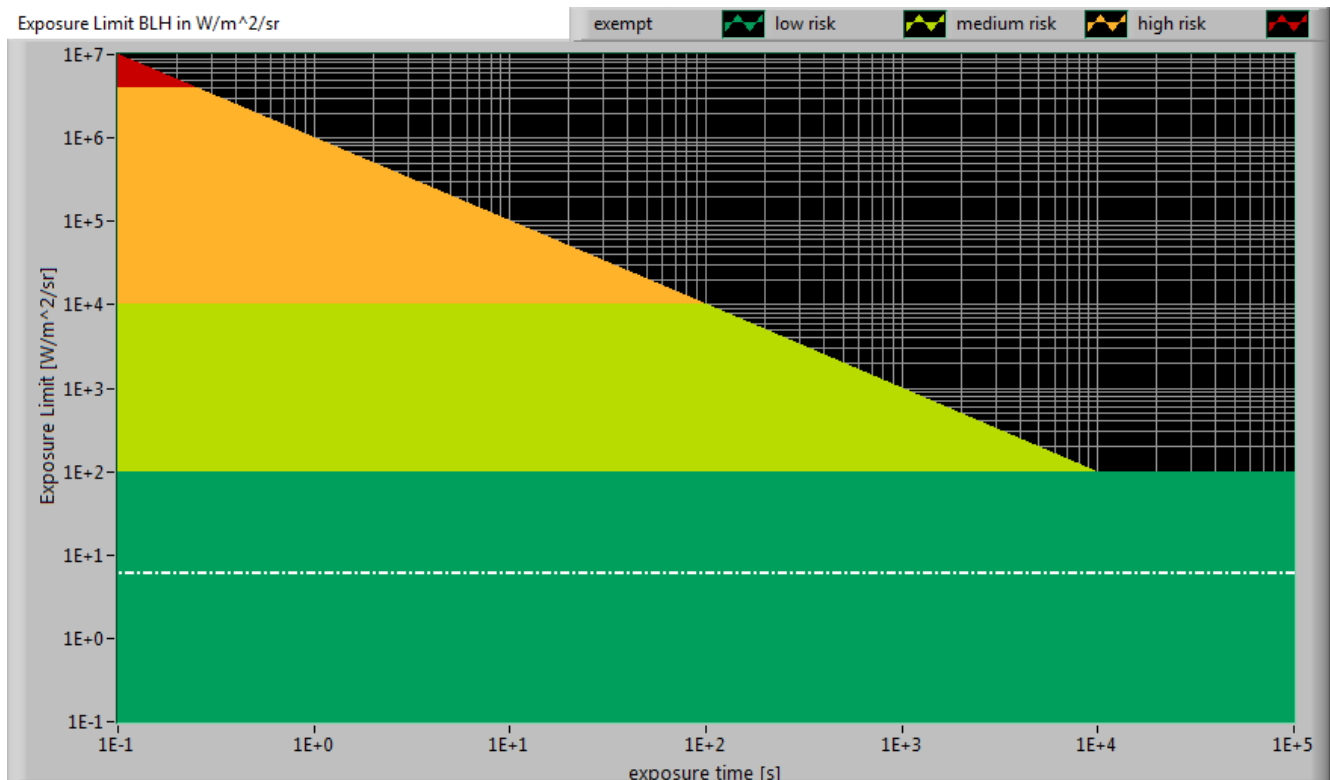
The melanopic effect shows the level of impact the light of this lamp can have on the day-night rhythm of human beings (as well as the suppression of melatonin production). The important parameters (according to norm DIN SPEC 5031-100:2015-08):

|                         |       |
|-------------------------|-------|
| melanopic effect factor | 0.520 |
| k_mel trans (25 years)  | 1.046 |
| k_mel trans (32 years)  | 1.000 |
| k_mel trans (50 years)  | 0.851 |
| k_mel trans(75 years)   | 0.621 |
| k_mel trans(90 years)   | 0.494 |
| k_pupil(25 years)       | 1.088 |
| k_pupil(32 years)       | 1.000 |
| k_pupil(50 years)       | 0.792 |
| k_pupil(75 years)       | 0.543 |
| k_pupil(90 years)       | 0.416 |

## Lamp measurement report - 18 Sep 2017

### Blue Light Hazard

The amount of blue light and the harm it can cause on the retina has been determined. Herewith the results.



The level of blue light of this lamp related to the exposure limit and the different classification areas.

|                                   |       |   |
|-----------------------------------|-------|---|
| L_lum0 [mm]                       | 26    | Dimension of brightest part of lamp in C0-C180 direction.   |
| L_lum90 [mm]                      | 1400  | Dimension of brightest part of lamp in C90-C270 direction.  |
| SSD_500lx [mm]                    | 1234  | Calculated distance where $E_v = 500$ lux. This computation is valid when it is in the far field of the lamp. Note: if this value 200 mm then the distance of 200 mm is taken as proposed in the norm IEC 62471:2006.                             |
| Start of far field [mm]           | 7001  | Minimum distance at which the lamp can be seen as a point source. In this area the $E_v$ is linearly dependent from $(1/\text{distance})^2$ .   |
| 300-350 nm values stuffed with 0s | yes   | In the event OliNo has measured with a SpB1211 spectrometer without UV option then the irradiance data of 300-349 nm is missing. For lamps where there is already no energy content near 350 nm, the values 300-349 can also be set at zero then. |
| alpha_C0-C180 [rad]               | 0.021 | (Apparent) source angle in C0-C180 direction.   |
| alpha_C90-C270 [rad]              | 1.135 | (Apparent) source angle in C90-C270 direction.  |



## Lamp measurement report - 18 Sep 2017

|                               |         |   |
|-------------------------------|---------|---|
| alpha_AVG [rad]               | 0.061   | Average (apparent) source angle. If average $\geq 0.011$ rad then the exposure limit is computed with radiance $L_b$ . Otherwise with irradiance $E_b$ .  |
| Exposure value [ $W/m^2/sr$ ] | 6.07E+0 | Blue Light Hazard value for this lamp, measured straight underneath the lamp. Computation is referenced to $L_b$ . Because the distance at 500 lux is in the near field, then this exposure value is too pessimistic and should be lower. |
| Blue Light Hazard risk group  | 0       | 0=exempt, 1=low, 2 = moderate, 3=high risk.   |

### Extra



*Additional photos.*

### Disclaimer

The information in this OliNo report is created with the utmost care. Despite this, the information could contain inaccuracies. OliNo cannot be held liable in this instance nor can the data in this report be legally binding.

We strive to adhere to all of the conditions of any copyright holder in the publication of any illustration/article or item. In the event that we unintentionally violate said copyright holder's conditions in our articles, we kindly ask to be contacted here at OliNo so that we can resolve any disputes, issues or misunderstandings.

### License

It is permitted ONLY to use or publish this report in its entirety and in unaltered form via internet or other digital or written media in any form. To guarantee the reliability and accuracy of the report, it is strictly prohibited to change or alter parts of the report and/or republish it in a modified content.