Photometric and electrical properties of the light sources

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Abstract: - The paper explores the effect of regulation and temperature on the photometric and electrical properties of the artificial light sources commonly used in residential and administrative buildings. While energy consumption for lighting systems is one of leading areas of usage, it is possible to improve this lighting system and reduce the energy consumption. While several theoretical approaches are available only some of them can be used, due to limitations of standards which set the quality of the luminous environment; for example, illuminance level, uniformity illuminance, the colour rendering respectively colour temperature or glare requirements. As a result of this limitations, this paper compares relative illuminance, colour temperature, spectral composition and I-V curve for different temperatures and regulation level to calculate ideal lighting system. For temperature regulation was used climatic chamber, which maintains selected temperature. For light source regulation was used KNX regulation actor. The measurement does not show considerable temperature impact on the photometrical or electrical properties of the artificial light sources. This fact will be used for calculation of the ideal luminous environment with economical energy consumption.

Key-Words: - Light source, regulation, temperature, illuminance level, I-V curve, spectral composition.

1 Introduction

Nowadays, when electric energy is used almost in all areas, higher efficient is required from electric devices. One of the leading areas of usage is Illumination. According to Şahin, 19 % of total amount of energy consumed is for illumination [1]. This quantity of energy encourages for improvement of the lighting solutions installed in buildings.

For example, Şahin described the usage of artificial neural networks for calculating the efficiency of the used lighting solution and the uniformity of its illuminance and as a result of these calculations optimal period of maintenance can be decided [1]. Another approach is optimisation of interior lighting as described Madia, in this solution, genetic algorithms were used for optimising illuminance and uniformity with no interventions to a building [2].

On the other hand, several studies compare different control approaches. Pandharipande described two architectures for lighting control centralised and distributed [3]. Roisin deal with individual daylight dimming system, movement detection switching, movement detection dimming and its combinations [4].

During daytime is appropriate using daylight. Han describing new developments in illuminations; for example, solar tubes or Mini-dish optical-fiber solar system for indoor illumination [5]. The shading control of daylighting through windows is described in several studies; for example, the subdivided window design with light shelves, which divide window to two parts, one with static light shelves and the second part with light shelves controlled by the occupant is presented by Sanati [6].

Due to this approach, our intention is to discover the effect of regulation on the photometric properties of the light sources. Because, no matter what approach is chosen, the light environment must fit the standards; for example, CSN EN 12464-1 [7].

Following part of this paper describes the measurement methods used for this measurement. This method includes temperature regulation and regulation of the light sources. In results part, the data for each light source are presented. The last part of this paper summarise results from the measurement.

2 Methods

This study was performed for common light sources used in residential buildings. Every light source was measured in a climatic chamber for several temperatures, specifically 0, 5, 10, 15 and 20 °C. Temperatures below 0 °C were not chosen due to impossibility measured photometric properties with provided measure head.

The measurement began with a time period when the light source was switch on with 100 % regulation level and the climatic chamber was set on one of the temperatures. This period lasts minimally 25 minutes.

During the measurement were recorded illuminance levels, colour temperature, spectral luminous efficiency, voltage, current and for verification temperature inside the climatic chamber. Those parameters were measured for the possibility to describe temperature effect on the photometric properties.

Figure 1 shows inside of the climatic chamber. Due to stainless steel walls inside the climatic chamber, these walls were covered with paper.

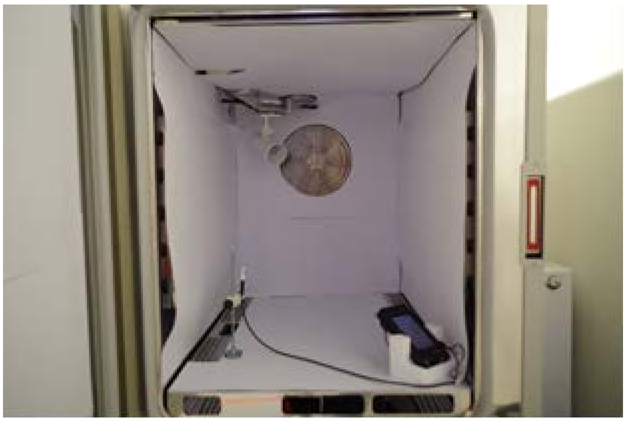
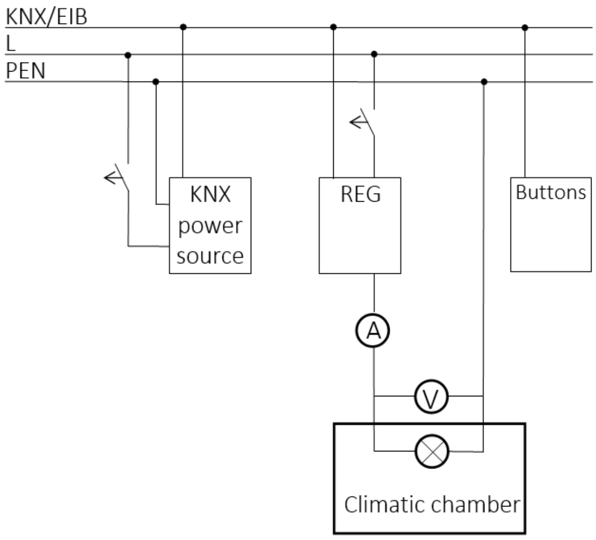


Fig. 1 climatic chamber with modification



L	-	Phase	V	-	Voltmeter
PEN	-	Protective earth, neutral	A	-	Ammeter
REG	-	Regulation element			

Fig. 2 diagram of the regulation circuit used for measurement

Figure 2 illustrate a diagram of the regulation circuit used for measurement. As could be seen only light source and measurement heads were inside the climatic chamber, regulation elements were stated out of the chamber.

The attributes of the measured light sources are given in Table 1, those attributes were read out from the wrapper. The light sources classic ECO halogen and LED premium were chosen as equivalent substitution for bulb light source.

Table 1 attributes of the light sources

Light source	**Power [W]**	**Colour temperature [K]**	**luminous flux [lm]**
Bulb	75	2700	940
Classic ECO halogen	53	2700	840
LED Premium	14	2500	995

3 Results

This article provides relative illumination in selected regulation levels, colour temperature and spectral composition of artificial lighting at different temperatures, also provides current–voltage characteristic and current-relative illuminance characteristic.

3.1 Bulb

The first artificial light source was the bulb.

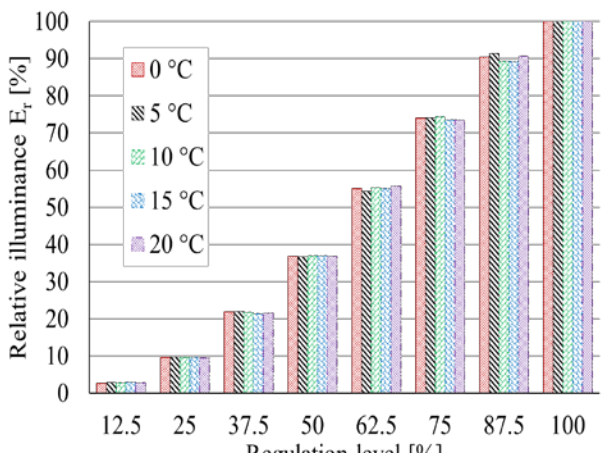


Fig. 3 relative illumination in selected regulation levels and temperatures (Bulb)

Figure 3 summarizes relative illumination in selected regulation levels and temperatures. From this figure conclude no obvious dependency on temperature. In several regulation levels, there is a small difference between relative illuminance but this difference is probably caused by measurement error.

Following Figure 4 colour temperature dependency on regulation levels and temperature shows difference at the lowest regulation levels, when the light source provides the lesser colour temperature at the lower temperature. Higher regulation levels, above 37.5 %, provide the equal colour temperature at all measured temperatures.

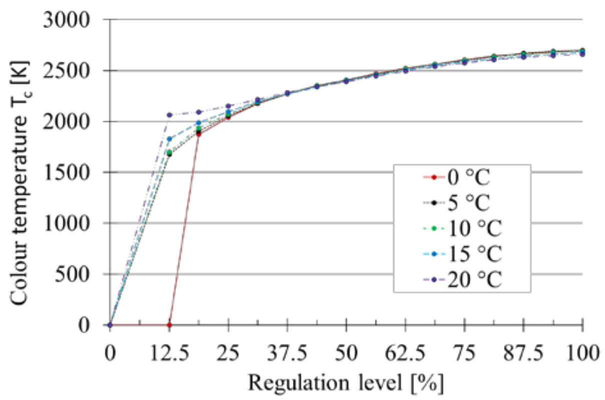


Fig. 4 colour temperature dependency on regulation levels and temperature (Bulb)

Figure 5 shows the spectral composition of artificial light at different temperatures and V(λ). This figure provides us only with the spectral composition at 50 % and 100 % regulation level. As can be seen there in no difference in spectral composition, the difference is only when the regulation level is changed.

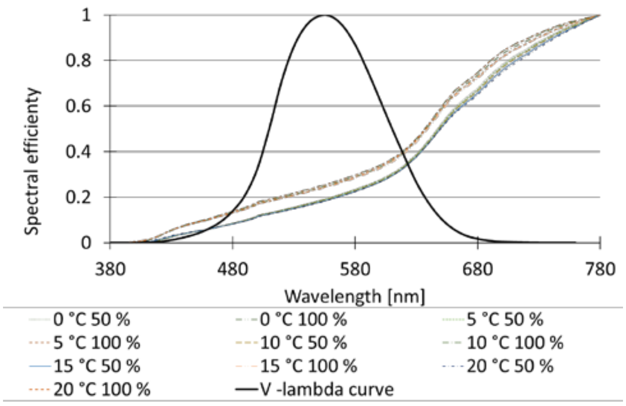


Fig. 5 spectral composition of artificial light source at different temperatures and V(λ) curve

Figure 6 provides I-V curves. As can be seen for temperatures 0, 5, 10 and 15 °C are curved greatly similar in low levels of regulation, only I-V curve for 20 °C is different. It is also evident, that the difference between current for different temperature is not as high as expected.

Figure 7 shows current dependency on relative illuminance which presents current consumed by the light source on different regulation levels and different temperatures.

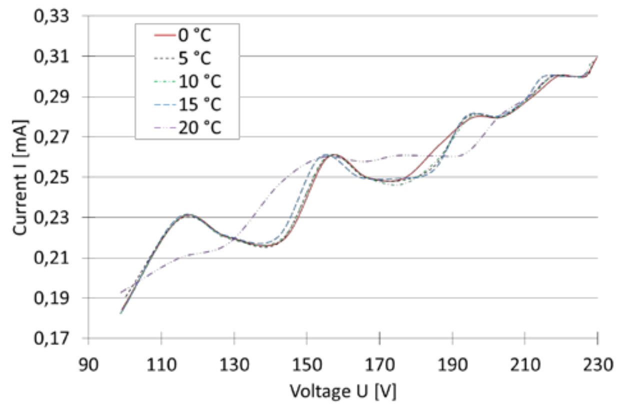


Fig. 6 I-V curves (Bulb)

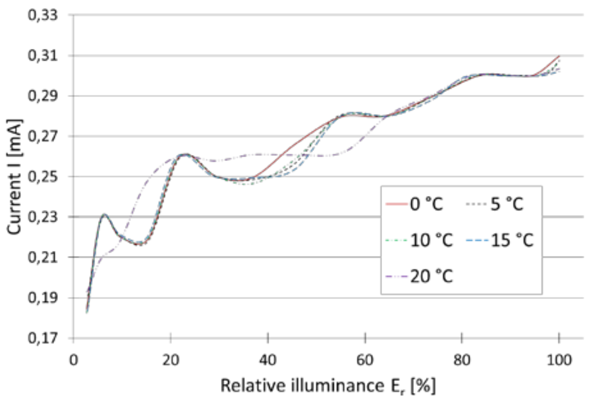


Fig. 7 current dependency on relative illuminance (Bulb)

3.2 Classic ECO halogen

The second light source was classic ECO halogen.

Figure 8 presents relative illumination in selected regulation levels and temperatures. As can be seen, there is also no obvious dependence on temperature as was not which bulb artificial light source. A small difference in several regulation levels is probably caused also by measurement error.

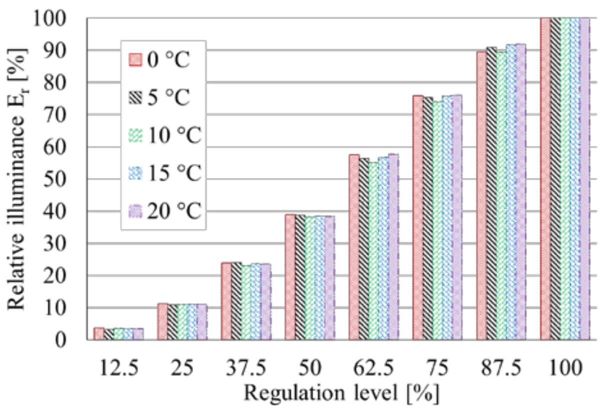


Fig. 8 relative illumination in selected regulation levels and temperatures (Classic ECO halogen)

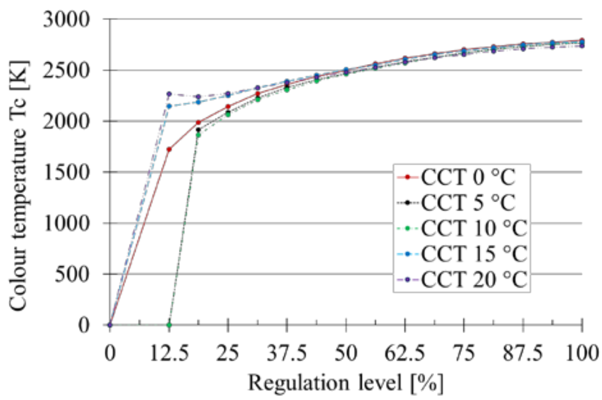


Fig. 9 colour temperature dependency on regulation level and temperatures (Classic ECO halogen)

Figure 9 illustrates colour temperature dependency on regulation level and temperature. According to the figure, the difference is only at lower regulation levels, but in this case, it is not the truth that the lower temperature provides lower colour temperature. Also higher regulation levels, above 43.75, provide the equal colour temperature at all measured temperatures.

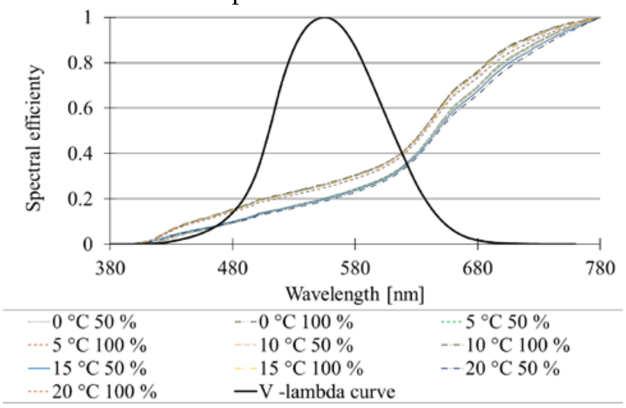


Fig. 10 Spectral composition of artificial light source (Classic ECO halogen) at different temperatures and V(λ) curve

Figure 10 shows the spectral composition of artificial light at different temperatures and V(λ) curve. This figure provides us only with the spectral composition at 50 % and 100 % regulation level. As can be seen there in no difference in spectral composition, the difference is only when the regulation level is changed.

Figure 11 provides I-V curves. As can be seen from this light source I-V curves are similar for temperature 0 and 5 °C. Also the fact, that current consumption is higher for higher temperatures is caused by a technology of the classic ECO halogen light source.

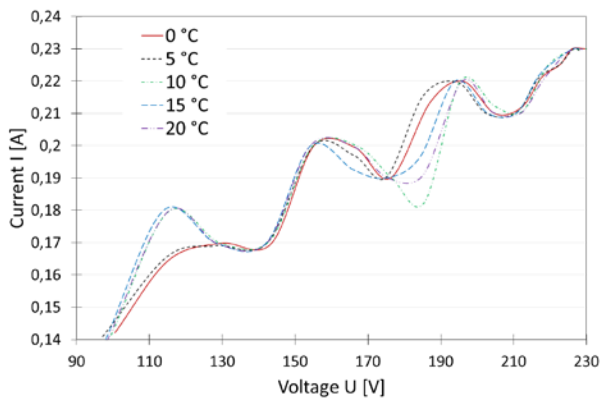


Fig. 11 I-V curves (Classic ECO halogen)

Figure 12 shows current dependency on relative illuminance which presents current consumed by the light source on different regulation levels and different temperatures.

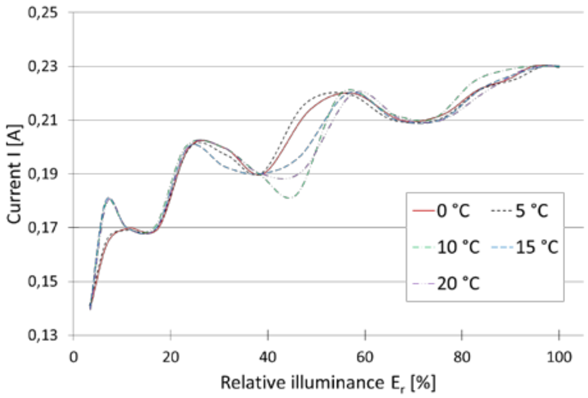


Fig. 12 current dependency on relative illuminance (Classic ECO halogen)

3.1 LED Premium

The third artificial light was LED premium.

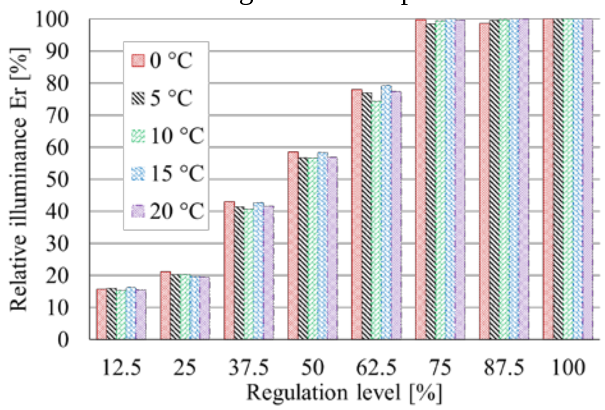


Fig. 13 relative illumination in selected regulation levels and temperatures (LED Premium)

Figure 13 shows relative illumination in selected regulation levels and temperatures. The figure illustrates no obvious dependence on temperature as were not in previous measurements. Same as in previous measurements there is a small difference in several regulation levels which is probably caused also by measurement error.

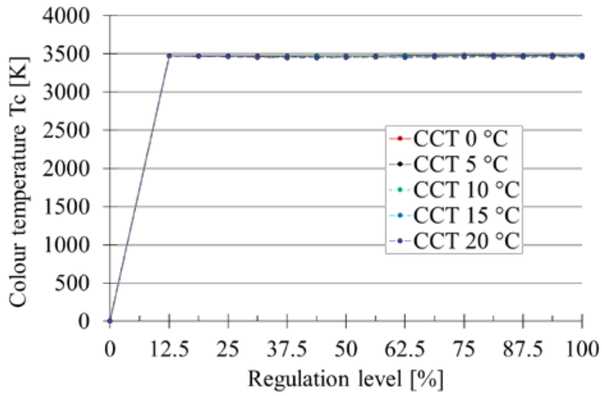


Fig. 14 colour temperature dependency on regulation level and temperatures (LED Premium)

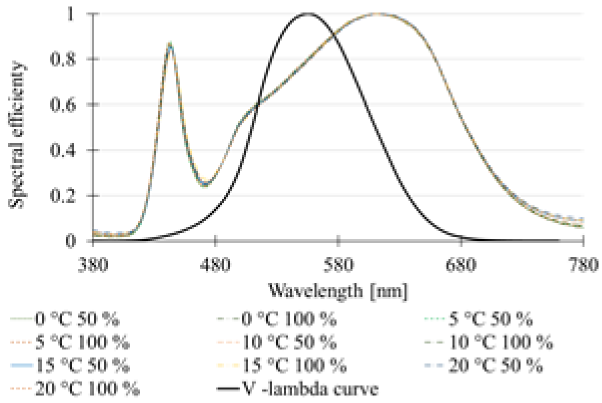


Fig. 15 spectral composition of artificial light source (LED Premium) at different temperatures and V(λ) curve

Figure 14 illustrates colour temperature dependency on regulation level and temperature. According to the figure, there is no difference in colour temperature in chosen regulation levels and temperatures.

Figure 15 show us spectral composition of artificial lighting at different temperatures and V(λ) curve. In this case, there is no difference in spectral composition of LED Premium artificial light source. Even different regulation levels do not have an effect on the spectral composition of LED Premium artificial light source.

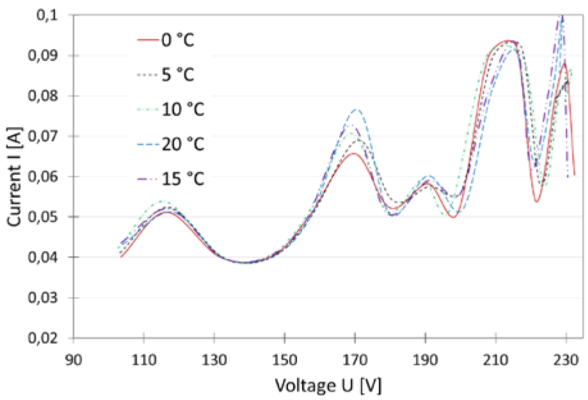


Fig. 16 I-V curves (LED Premium)

Figure 16 provides I-V curves. As can be seen for LED Premium light source are I-V curves similar in low voltage, low levels of regulation, but for higher voltage, regulation level set at 50% and higher, are I-V curves different. This fact presents I-V curve dependency on temperature.

Figure 17 shows current dependency on relative illuminance which presents current consumed by light source on different regulation levels and different temperatures.

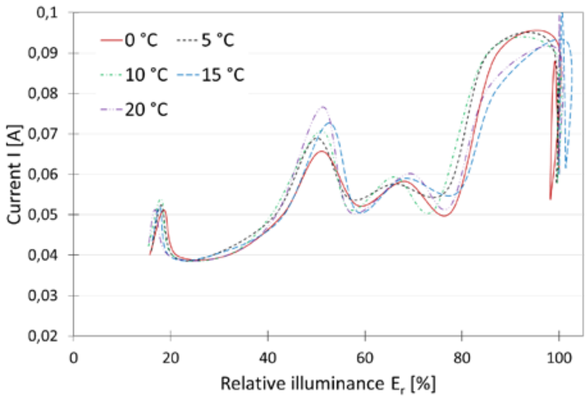


Fig. 17 current dependency on relative illuminance (LED Premium)

4 Conclusion

This article describing temperature effect on the photometric and electrical properties. As can be seen from Figures 3, 8 and 13 shows that the temperature in the range between 0 °C to 20 °C do not have an effect on the illumination, the small difference in regulation levels is probably caused by measurement error, due to this difference is under 2 %. Figures 4, 9 and 14 summarises colour temperature dependency on regulation level and temperature. For bulb and classic ECO halogen, there is the difference in lower regulation levels; however, due to low levels of illumination in this regulation levels, use of those regulation levels are limited. For LED premium, there is no difference in measured points and colour temperature is constant; however, the difference can be seen between value what was measured and what producer provide. Figures 5, 10 and 15 present spectral compositions of the artificial light source at different temperatures. As can be seen from those figures temperature does not have an effect on spectral compositions. An effect on spectral composition have only regulation levels, but only for the bulb and the classic Eco halogen, for the LED premium the spectral composition is almost comparable to each regulation level and temperature.

Figures 6, 11 and 16 shows I-V curves which provide basic illustration of energy consumption during regulation. Figures 7, 12 and 17 summarises current dependency on relative illuminance, which can be used for basic energy consumption calculation.

As introduce above the measurement was performed for the temperatures in the range between 0°C to 20 °C, the temperatures in which those light sources will be commonly used. The measurement should be done for compact fluorescent light, but due to undefined regulation problems the measurement will be repeated shortly. In future research, the temperature below 0 °C will be measured for clarification effect on the photometric and electrical properties.

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