

## LED Lighting - Error Consideration for Illuminance Measurement

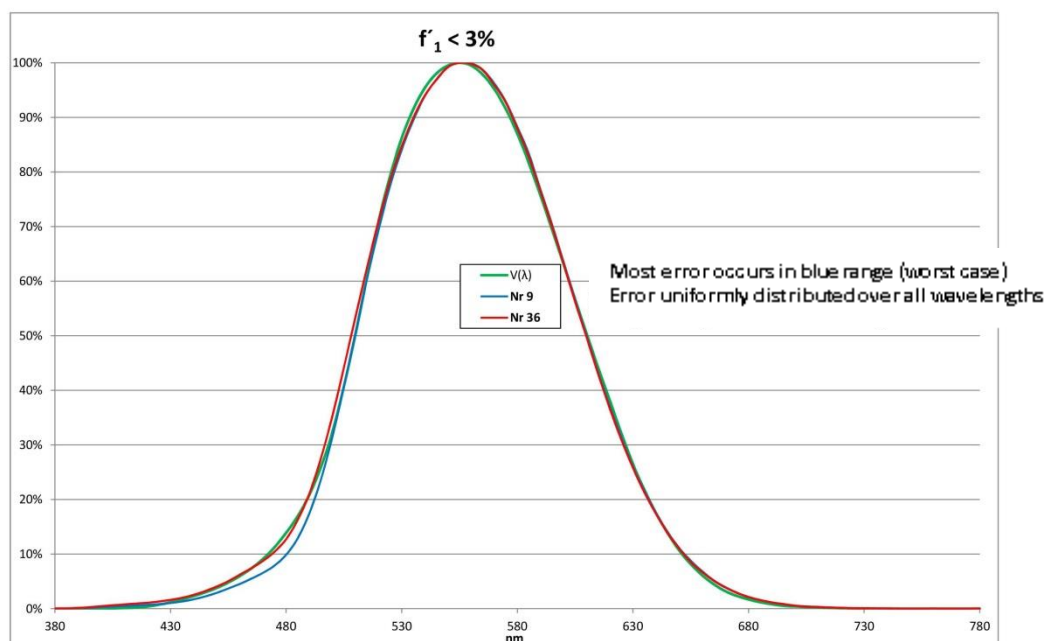
One of the most important characteristics of a luxmeter is matching to the sensitivity of the human eye  $V(\lambda)$ .  $V(\lambda)$  is the spectral luminous efficiency of the human eye in daylight, and is defined in DIN 5031. The required matching is accomplished by means of an optical filter whose quality dictates the accuracy class. Permissible deviation is specified in DIN 5032 and DIN EN 13032 for the individual classes.

Permissible deviation for  $V(\lambda)$  matching makes reference to light type A (incandescent light at 2856 K). In the case of lamps with an extremely discontinuous spectrum or a very narrow-band spectrum, error may be significantly greater. Typical lamps with these spectra include LEDs.

In the case of LEDs, white light is generated either from a blue LED with a conversion coating (usually phosphorus) or in accordance with the RGB principle by means of one red, one green and one blue LED. With both processes, large spectral components occur on the rising or falling edge of the spectral sensitivity of the human eye in daylight  $V(\lambda)$ . The quality of  $V(\lambda)$  matching is especially important within these ranges, for which reason the use of more precise, class B devices in accordance with DIN 5032-7 and DIN EN 13032-1 is recommended.

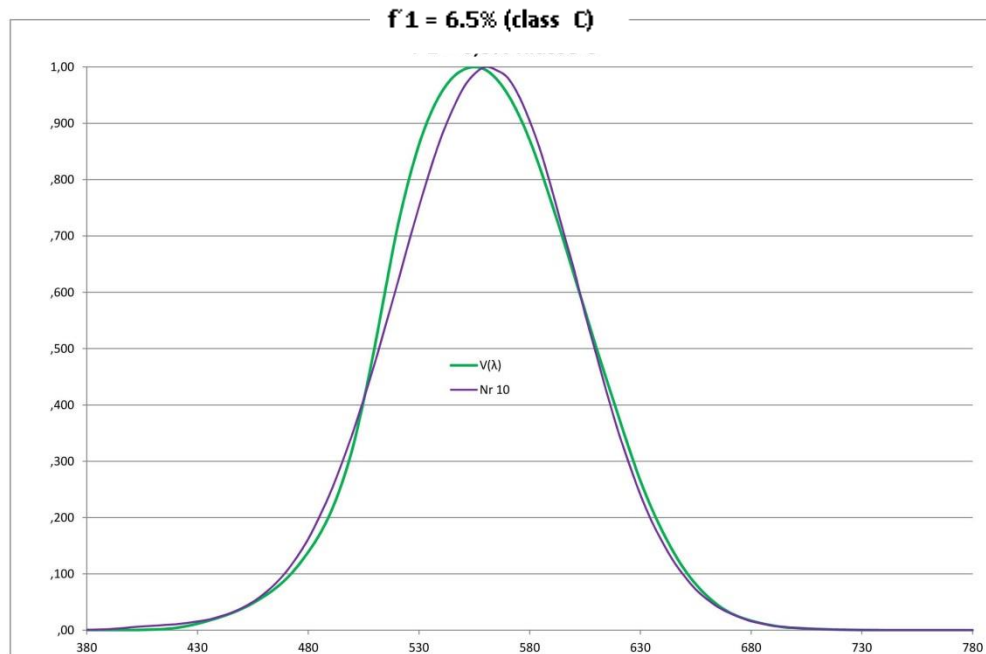
When examining class B and class C luxmeters by performing measurements at white and single-color LEDs, we see how important  $f_1$  error is for the accuracy of the measurement results.

Various white and colored LEDs were examined as described below with our filtering for luxmeters. For the purposes of this investigation, two typical filterings with an  $f_1$  error of less than 3% (corresponds to class A) were used, as well as a third filtering with an  $f_1$  error of 6.5% (corresponds to class C).



Using the filters identified as no. 9 and no. 36,  $f'1$  error is less than 3% in both cases.  $f'1$  error is the sum of the surfaces which deviate from the  $V(\lambda)$  curve relative to total surface area underneath the  $V(\lambda)$  curve. In the case of filter no. 9, error occurs almost exclusively within the blue range from 400 nm to roughly 500 nm, and for filter no. 36, error is uniformly distributed over the entire wavelength range. All possible variants between these two extremes can occur with our class B(A) filters.

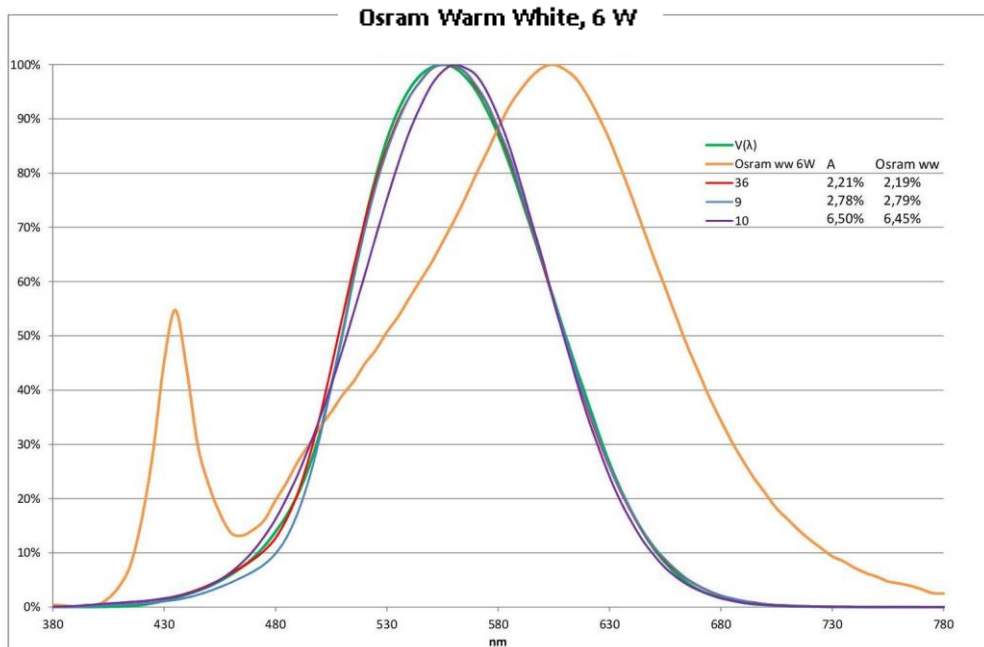
Filter no. 10 is a typical filter for a class C meter. As we can see, deviation from the  $V(\lambda)$  curve is distributed relatively uniformly over the entire wavelength range in this case as well, although on the whole it's larger.



If different LEDs are now measured with these receivers, we arrive at the following results.

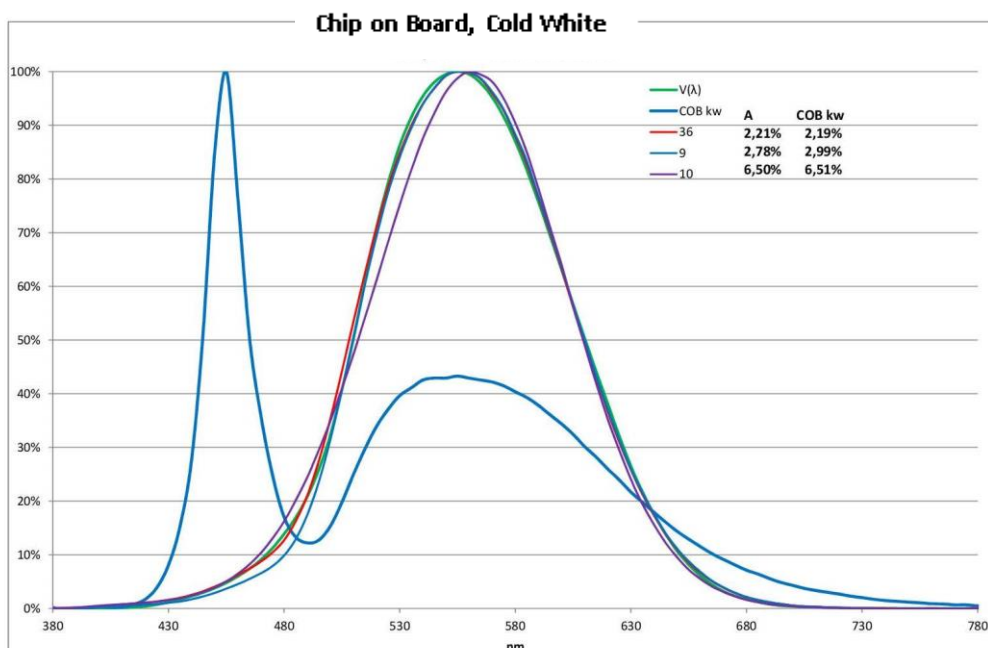
## White LEDs for the Purpose of Illumination

The OSRAM warm white 6 W is a typical white LED. It's based on the principle of a blue LED with a fluorescent coating.



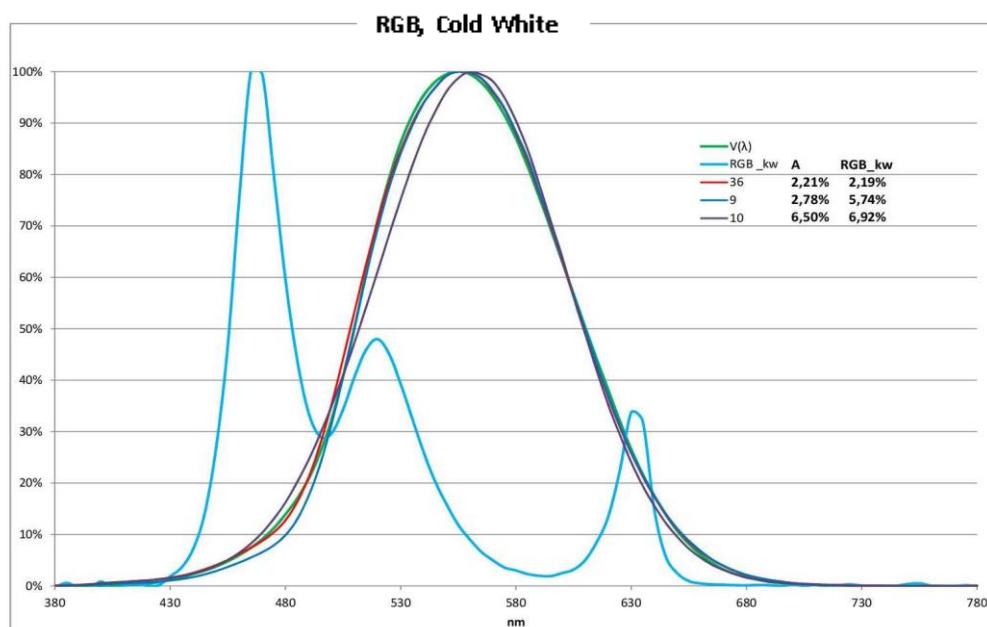
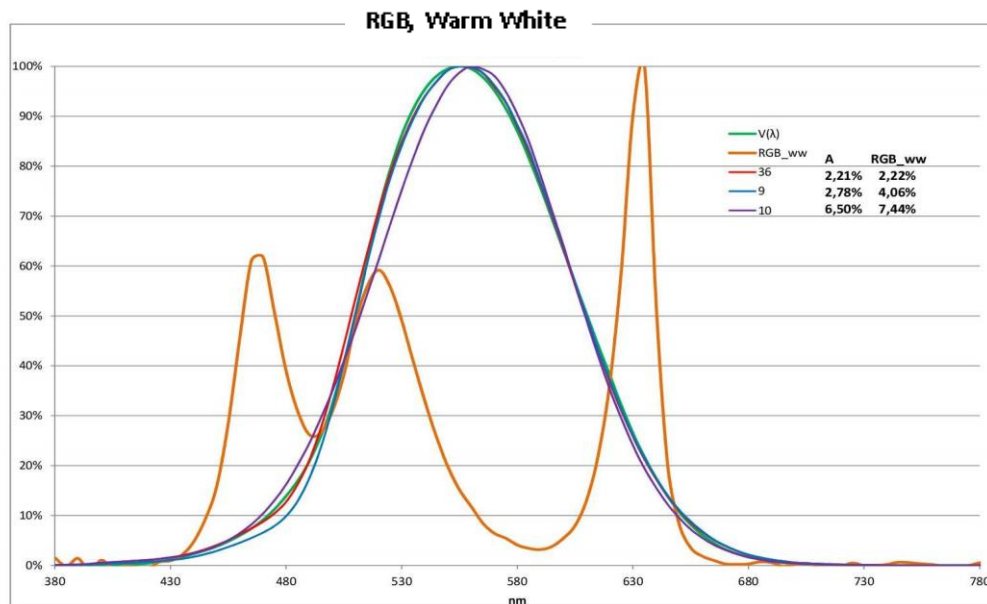
As we can see, error does not change for this LED with matching to the sensitivity of the human eye. For all three filterings, error with  $V(\lambda)$  matching is practically identical to error for light type A.

The COB (chip on board) is another white LED. With this design, the blue LED is attached directly to the aluminum base and covered with a yellow-orange fluorescent coating.



With this LED as well, f1 error remains unchanged. It's practically identical to error for light type A with all three filterings.

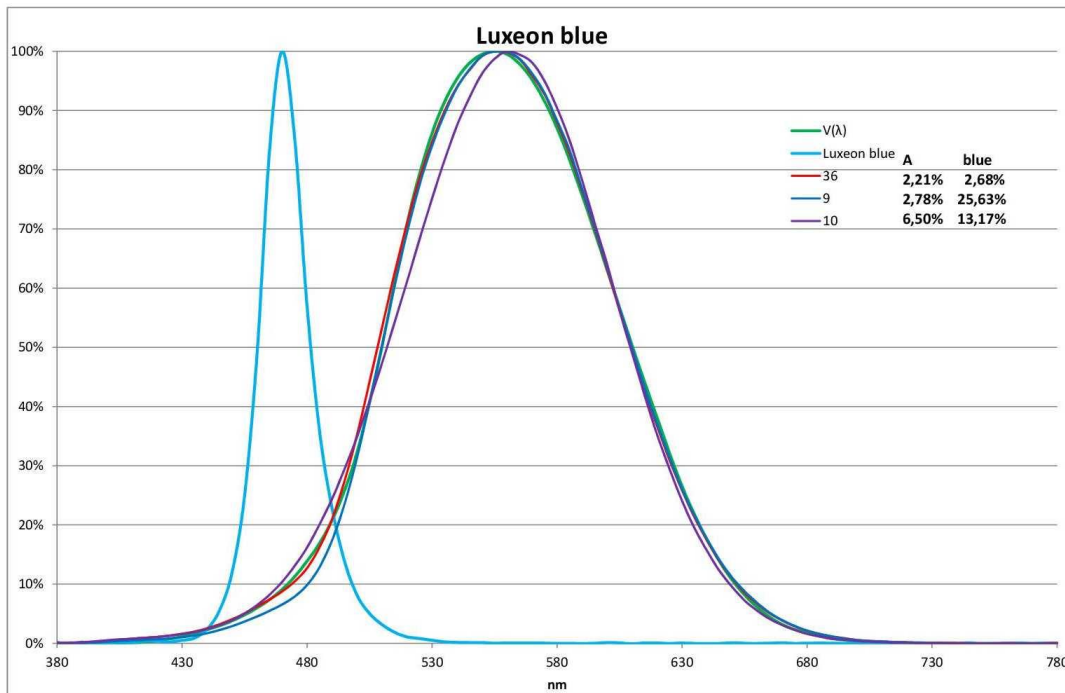
Next we'll examine a white LED based on a combination of three LEDs in the colors red, green and blue. Warm or cold white light can be generated by controlling the three LEDs differently.



For these two white LEDs, by means of which white light is generated by variably controlling one red, one green and one blue LED, filtering error is greater relative to light type A, although it's not yet significant.

## Colored LEDs for Effect Lighting

In the case of red, orange, green and blue-green LEDs, no deviation of f1 error can be detected relative to light type A. Only blue LEDs constitute an exception.



In the case of the blue LED with filter no. 9, a considerable difference relative to error with light type A becomes apparent.

## Conclusion

Class A/B and C luxmeters with matching to the sensitivity of the human eye are very good for measuring LEDs used for lighting. In the case of LEDs used for background illumination in LCDs (e.g. in automobile dashboards), error may be considerably greater than is the case with light type A. Equally these results can be used for the GOSSEN luminance meters because they are using the same filter as the luxmeters.

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