White paper for Standard Pro plus Neutral Density filter to replace the High Lux Lighting Passport

By: Rez Mani (Application Scientist, Allied Scientific Pro)

In this white paper, it is proposed to replace the Lighting Passport High Lux model which is capable of measuring illuminances up to 200,000 lux with a Standard Pro model and a neutral density filter coupled to the aperture. The High Lux model has been discontinued and the Standard Pro model is only capable of measuring up to 50,000 lux. Customers who would like to measure the illuminances of their high intensity fixtures and with the discontinuation of the High Lux model, have no means to do it.

The idea is to use an OD 0.6 neutral density filter that works in the visible range and has a transmission of nearly 20% to be placed on the diffuser of the Standard Pro to measure high intensity light fixtures. What needs to be calculated is the exact multiplication factor to be used once the Standard Pro measures the illuminance with the neutral density filter to give the actual illuminance. In addition, it has to be investigated if the presence of the ND filter alters the other photometric and colorimetric parameters such as colour temperature, CRI index and TM30's R_f and R_g values.

To accomplish this, the neutral density filter FROD60 from Newport was used. This ND filter is of the absorptive type and has the following specs.

12.7 mm diameter, OD=0.6 at 546.1 nm (20% transmission nominal) and is shown in figure 1.

Figure 1: FROD60 from Newport

In order to make consistent measurements and eliminate variation due to spatial variability, a filter holder was designed that would clip on the Standard Pro spectrometer and holds the ND

filter with a screw on top of the diffuser. This filter holder with the filter in place is shown in figure 2.

Figure 2: Filter holder to hold the ND filter in front of the standard Pro diffuser plate

The next step was to measure transmittances of the filter at high intensities for lamps of different colour temperatures. This has been done and the Spectrum Genius Transmission (SGT) app was used to determine the transmission of the filter for these light sources. For the transmission measurement, the High lux unit was used with and without the filter.

Two 90 watt lamps of different colour temperatures, one at 5000 K and the other at 3000 K were used to make these measurements and the following results were obtained.

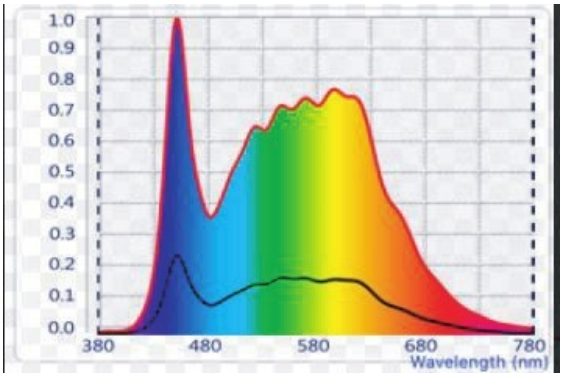
The illuminance levels were adjusted by different positioning of the Hi Lux unit with respect to the light source and measurements were done at 50,000, 100,000, 150,000 and 200,000 lux. The tables and pics in Section 1. show the results. The High Lux unit has some data filtering issues and ripples appear on the spectrum. This does not affect the transmittance measurement since both the filtered and unfiltered units have these ripples. However, it does affect the photometric measurements which will be discussed later.

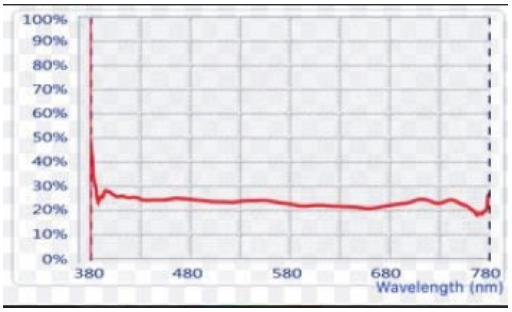
Section 1: Transmission measurements of the neutral density filter

1- 90 watt, 5000 K lamp

1.1 Measurement at 50,000 lux

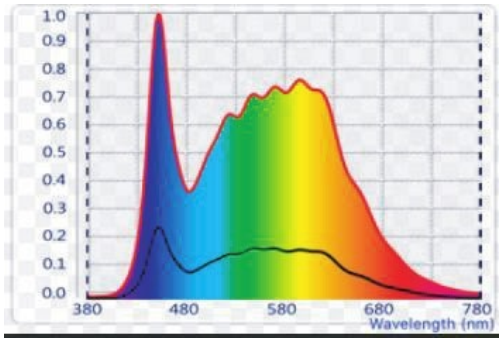
Average Transmittance	24%
Photopic Transmission	23%
Wavelength Range	380nm ~ 780nm
Transmittance	24%
Rejection	76%

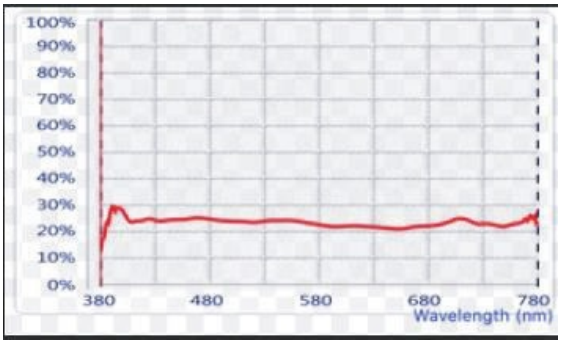




1.2 Measurement at 100,000 lux

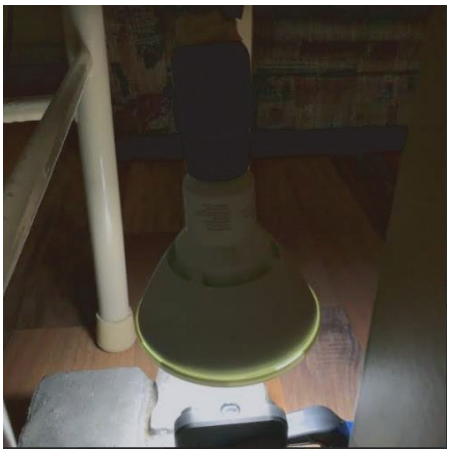
Average Transmittance	24%
Photopic Transmission	23%
Wavelength Range	380nm ~ 780nm
Transmittance	24%
Rejection	76%

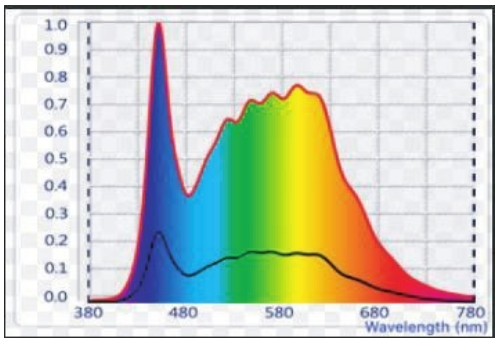


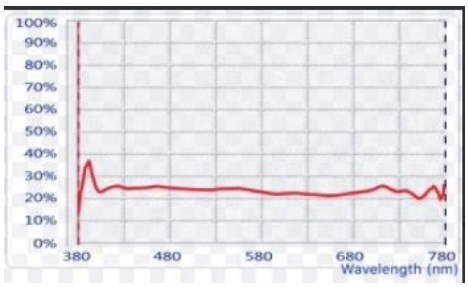


1.3 Measurement at 150,000 lux

Average Transmittance	24%
Photopic Transmission	24%
Wavelength Range	380nm ~ 780nm
Transmittance	24%
Rejection	76%

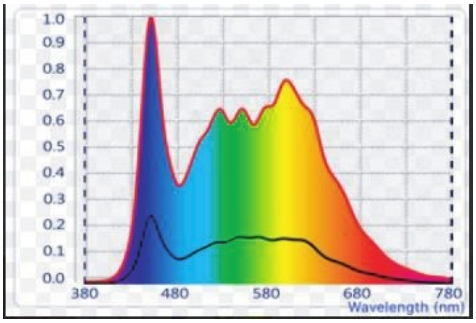


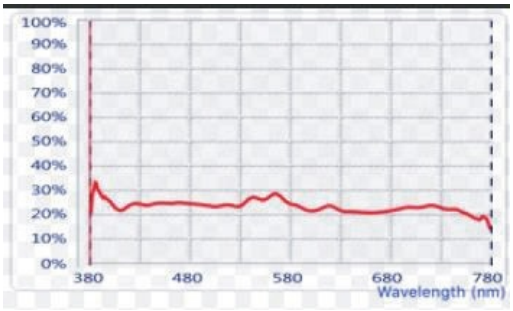




1.4 Measurement at 200,000 lux

Average Transmittance	24%
Photopic Transmission	25%
Wavelength Range	380nm ~ 780nm
Transmittance	24%
Rejection	76%





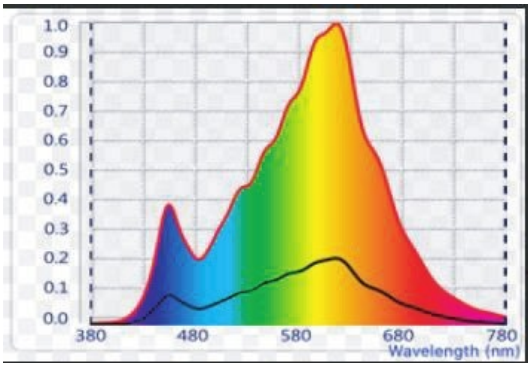
Average of 4 measurements for 5000 K lamp was 24%.

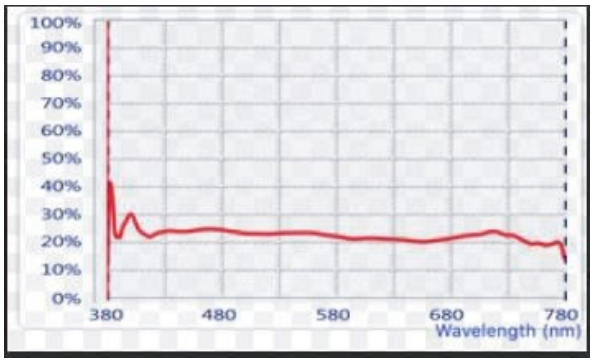
Illuminance (Lux)	Filter transmission
50,000	24%
100,000	24%
150,000	24%
200,000	24%
Average	**24%**

1- 90 watt, 3000 K lamp

2.1Measurement at 50,000 lux

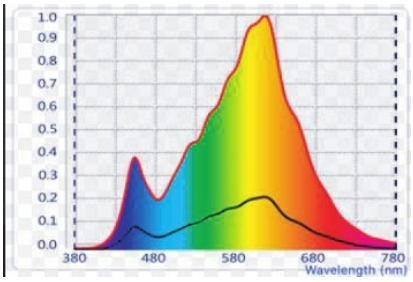
Average Transmittance	23%
Photopic Transmission	23%
Wavelength Range	380nm ~ 780nm
Transmittance	23%
Rejection	77%

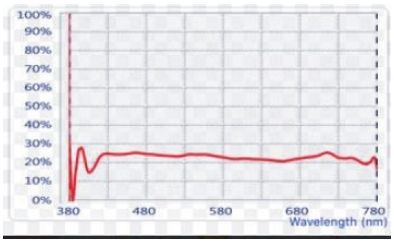




2.2 Measurement at 100,000 lux

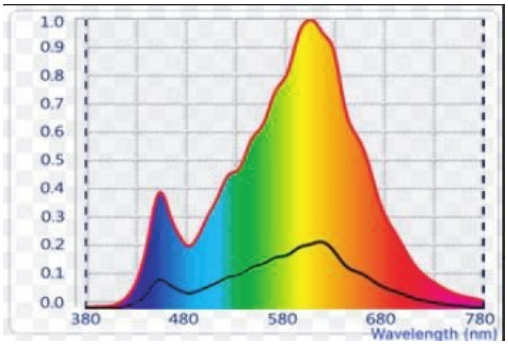
Average Transmittance	23%
Photopic Transmission	23%
Wavelength Range	380nm ~ 780nm
Transmittance	23%
Rejection	77%

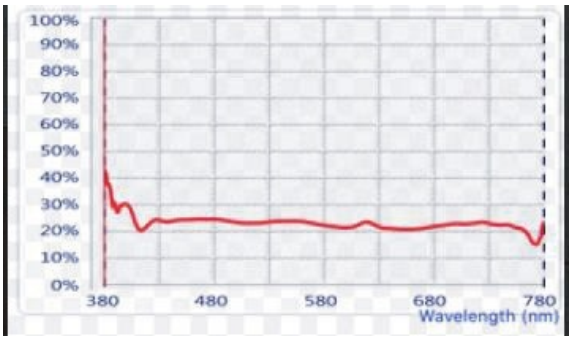




2.3 Measurement at 150,000 lux

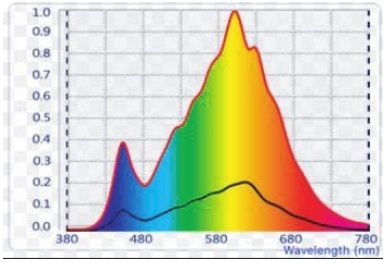
Average Transmittance	24%
Photopic Transmission	23%
Wavelength Range	380nm ~ 780nm
Transmittance	24%
Rejection	76%

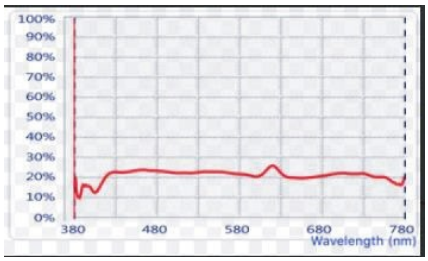




2.4 Measurement at 200,000 lux

Average Transmittance	22%
Photopic Transmission	22%
Wavelength Range	380nm ~ 780nm
Transmittance	22%
Rejection	78%

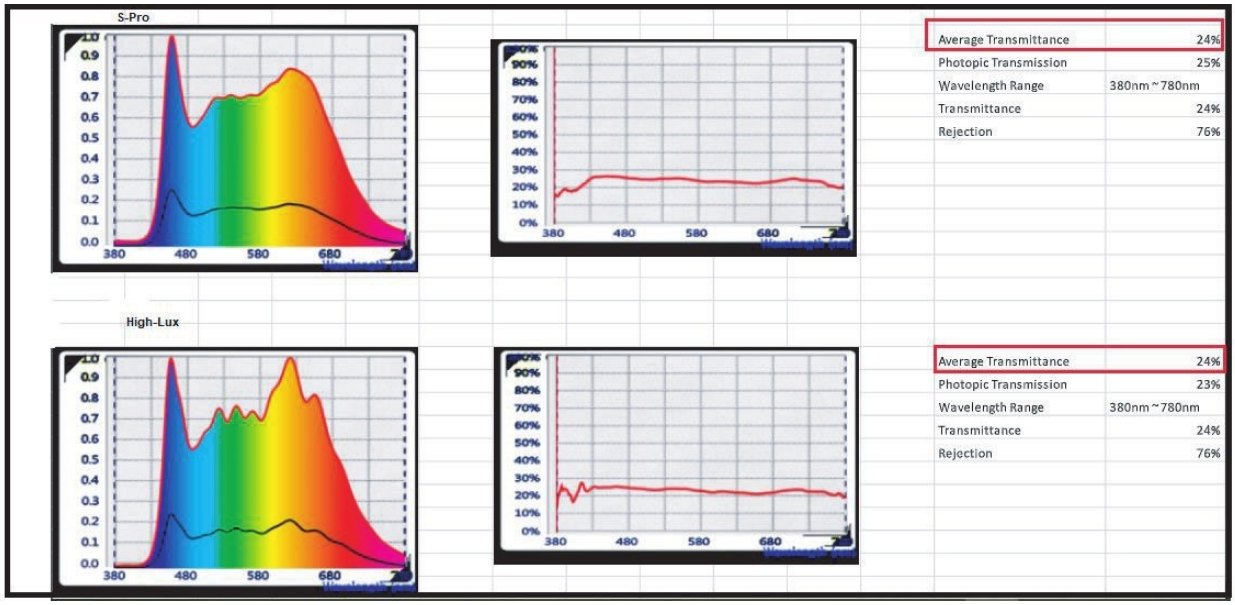




Average of four measurements for the 3000 K lamp was 23%.

Illuminance (Lux)	Filter transmission
50,000	23%
100,000	23%
150,000	24%
200,000	22%
Average	**23%**

The same type of transmission measurement was done by Les Kacev from the company LEDmetric in California using the SGT app and the Hi Lux model using different light sources. The following results were obtained.



Les did the measurements with and without the filter using both the high intensity and the standard pro units and in both cases he measured 24% for the ND filter transmission.

THEREFORE WE RECOMMEND A MULTIPLYING FACTOR OF 1/0.24=4.17 WHEN THE NEUTRAL DENSITY FILTER IS USED IN COMBINATION WITH THE STANDARD PRO TO MEASURE ILLUMINANCE LEVELS.

Section 2: Measurements of colour temperature, TM30 parameters and other colorimetric parameters with and without the neutral density filter.

The High Lux unit had issues with data filtering and ripples were observed on the measured spectrum. Conversely, the spectrum measured by the Standard Pro is ripple free. Since, the TM30 and CRI values are directly calculated from the measured spectrum, it was not possible to compare the spectrum measured by the High Lux model with the spectrum measured by Standard Pro in combination with the neutral density filter for high intensity sources. This would produce big differences in TM30 and CRI values. The methodology was to use the Standard Pro with and without the filter to measure the spectrum and compare TM30 and colour temperature values. Although the Standard Pro has not been calibrated to measure illuminances above 50,000 lux, it can still measure the spectral profile correctly from sources with illuminances higher than 50,000 lux.

Two examples are given here for 100,000 lux illuminance level for a 5000 K and a 3000 K lamp fixtures.

Test 1: 5000 K light fixture at 100,000 lux.

The raw spectrum (Pink Colour) shows a slight asymmetry around the broad peak but when the filter is used (Green spectrum) the broad peak becomes symmetrical (Figure 1)

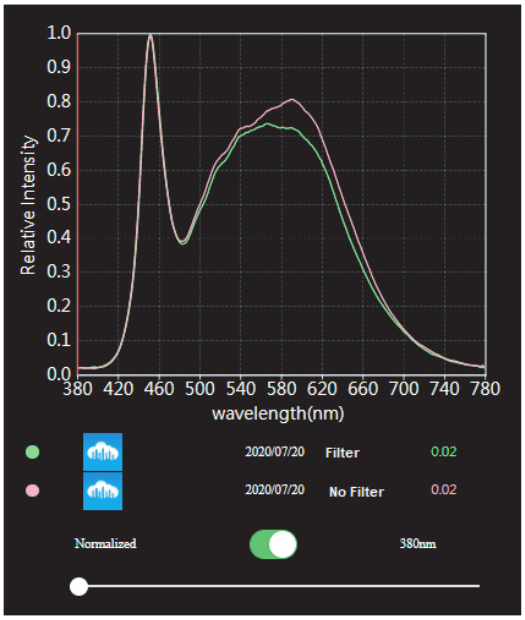
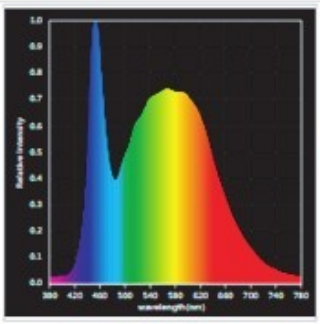


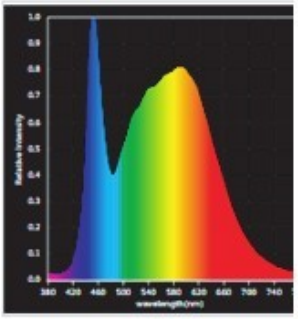
Figure 1: Comparing the filter with no-filter spectra

The measured parameters are shown below in figure 2.



Filter

NoFilter



2020/07/20	Record name	2020/07/20
5000 K	CCT	4686 K
0.0043	Duv	0.0024
85	CRI (Ra)(R1~R8)	86
79	CRI (Re) (R1-R15)	80
84	CQS	85
77	TLCI(Qa)	77
81	GAI	80
	TM-30-15 Rf	
	TM-30-15 Rg	
86	TM-30-18 Rf	86
95	TM-30-18 Rg	96
23237 lux	Illuminance	97491 lux

Figure 2: comparing the measured parameters of filter with no filter

As can be seen in the table of comparison, Rf and Rg values are almost equal and CCT of no filter case is 7% higher. The CRI comparison table is shown in figure 3.

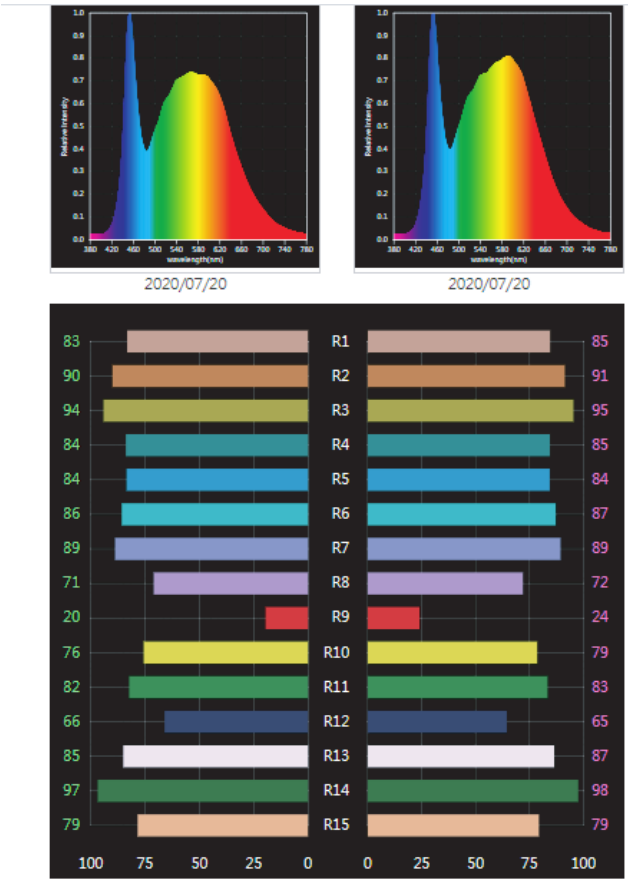


Figure 3: CRI comparison table

Most of the indices are the same except for R9 which is lower by 20% for ND filter as compared to no ND filter use.

Test 2: 3000 K light fixture at 50,000 lux.

The raw spectrum (Green) and the filtered spectrum are almost similar except that the filtered spectrum has a relative higher blue peak. This is shown in figure 4.

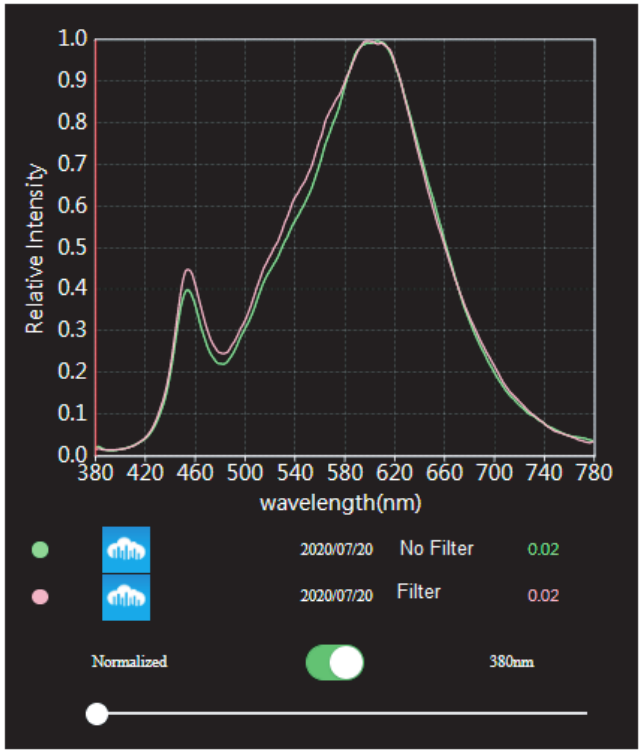
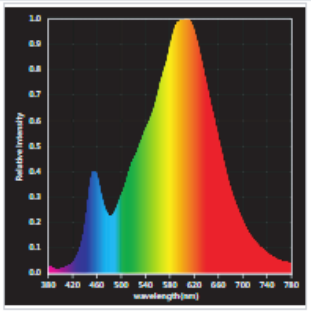


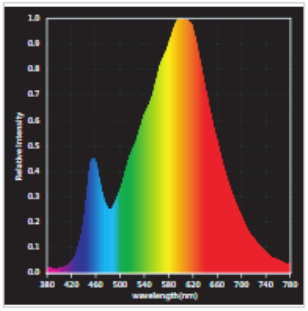
Figure 4: Filtered and unfiltered spectra comparison

The comparison of colorimetric parameters is shown in figure 5.



No-Filter

Filter



2020/07/20	Record name	2020/07/20
2944 K	CCT	3105 K
0.0011	Duv	0.0024
82	CRI (Ra)(R1~R8)	82
76	CRI (Re) (R1-R15)	76
84	CQS	84
71	TLCI(Qa)	73
50	GAI	52
	TM-30-15 Rf	
	TM-30-15 Rg	
85	TM-30-18 Rf	85
94	TM-30-18 Rg	94
48858 lux	Illuminance	11206 lux

Figure 5: Comparison of colorimetric parameters between filter and no filter cases

Once again the TM30 R_f and R_g values are identical and the CCT of the ND filter case is 5% higher.

The CRI value comparison table is shown in figure 6.

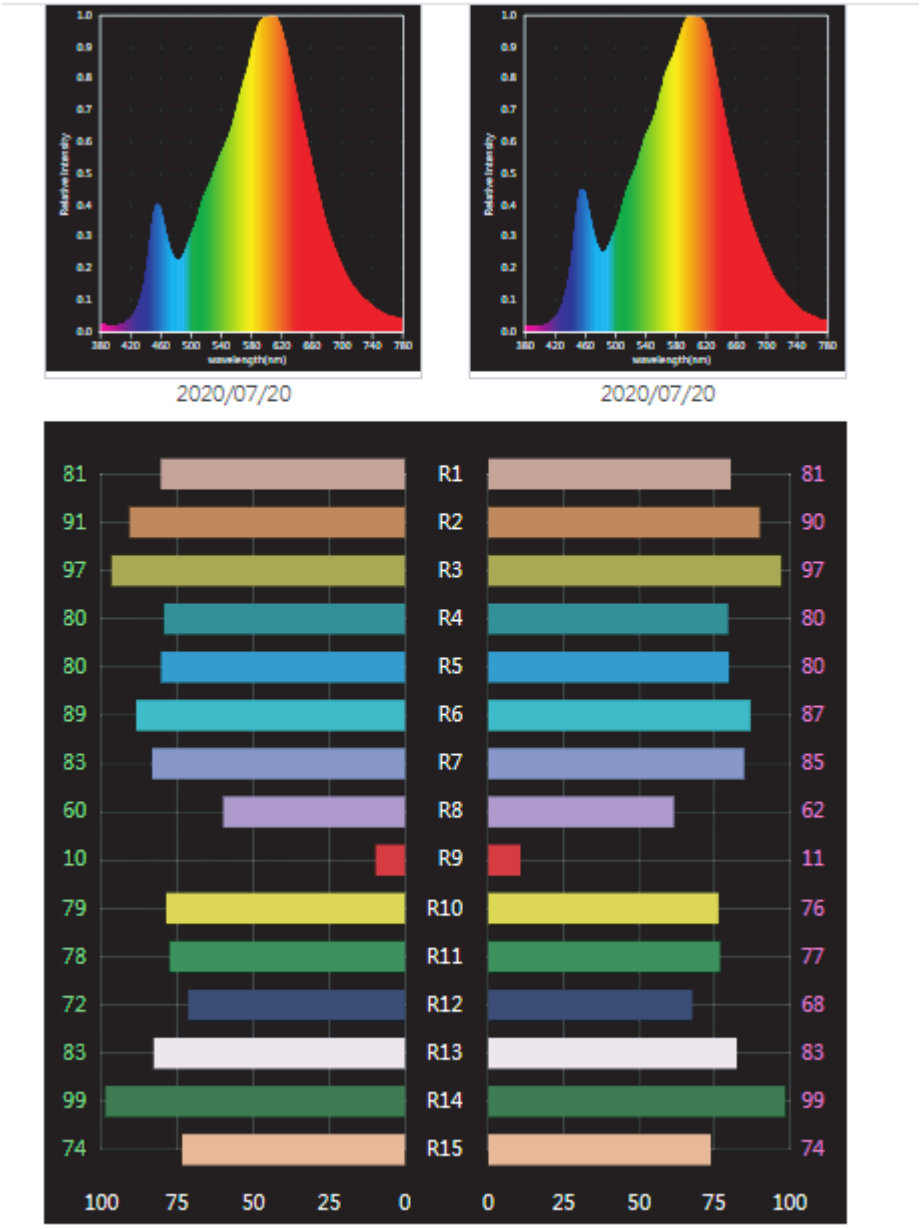


Figure 6: Comparison of CRI values between ND filter and no ND filter cases

The values are almost the same.

Photometric test conclusions:

WE CONCLUDE THAT THE USAGE OF A ND FILTER DOES NOT ALTER THE TM30 VALUES AND THE CRI INDICES. HOWEVER IT INCREASES THE CCT BY 5-7%.

Allied Scientific Pro's Recommendation on usage of ND filter for high lux measurements:

- The recommended ND filter can be used for measuring illuminances greater than 50,000 lux. The measured illuminance should be multiplied by a factor of **4.17** to get the correct illuminance.
- The TM30 Rf and Rg values will not be altered by the presence of the ND filter
- The colour temperature increases by 5 to 7% when the ND filter is used. Multiply the measured colour temperature by 0.93 to get the correct colour temperature.