LIGHT AND COLOR, ARTISTIC ASPECTS OF LIGHTING

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Abstract - Current recommendations for museum lighting practice are broadly in agreement that ultraviolet (UV) should be severely restricted or eliminated and that exposure to light should be limited in both intensity and duration . For exhibits that are categorized as highly susceptible to exposure damage, the recommended maximum illuminance is 50 lux, which is recognized as the lowest practical level for exhibits for which color discrimination is an important factor While there are no specific standards for infrared (IR) control, dichroic reflector spotlights are generally recommended. The mirror that forms the beam for this type of spotlight has a wavelength-selective reflecting surface that directs light, but not IR, into the beam. Generally, current practice for museum display lighting utilizes incandescent filament light sources, such as the MR lamp (a tungsten halogen source with integral multifaceted dichroic reflector, usually 2 in. in diameter). The spectral power distribution for this type of illumination is characterized by a continuous, smooth curve throughout the visible spectrum, increasing toward the long-wavelength end.

Key words: lightning, museum, illumination, spectral power distribution

1. LIGHTING AND THE COLOR APPEARANCES OF EXHIBITS

Although radiant luminous efficacy provides a useful basis for comparing the damage potential of alternative light sources, it is far from being the whole story. A critical concern in museum lighting is how the illumination affects the appearance of colored materials. Consequently, this study was designed to relate the spectral power distribution of lighting to the responses of subjects viewing artworks in a simulated art gallery setting. The color rendering index (CRI) of a lamp is defined by a procedure that compares measurements relating to the color of the light reflected from a set of reference-colored samples illuminated by the lamp with the light reflected from the same samples when illuminated by a black body source having the same CCT as the lamp. (A different type of comparison source is used where CCT>5000 K.) If all of the samples match perfectly under both sources, the lamp is accorded a CRI of 100. Any departures from a perfect match reduce the CRI. This procedure assumes that, for low and intermediate color temperatures, the theoretical black body is the ideal color rendering source.

2. METHODS AND MATERIALS

The experiment consisted of identical reproductions of artwork presented in two adjacent simulated art gallery settings, one the test situation and the other the comparison situation. Subjects adjusted the illuminance in the test situation to match the appearance of the comparison situation. The comparison situation was always illuminated to 50 lux by an MR lamp, and the test situation was illuminated alternately by an MR lamp and an experimental three-band light source. The settings were recorded and compared to see whether there were differences in the illuminances that subjects selected to achieve similar appearances. Differences of irradiance were calculated from the recorded illuminances. Also, subjects were questioned on any differences of appearance they noticed after making each setting. Figura 1 shows the spectral power distribution , operating on slightly reduced voltage to provide 50 lux in the experimental situation with a CCT of 2850 K. Note the characteristic smooth, continuous curve climbing toward the long-wavelength end of the spectrum. The decline above 700 nm is due to the dichroic reflector, which is partially transparent to IR and extreme long-wavelength visible radiation.

While a practical three-band light source for museum use will consist of a single lamp, with or without a filter, for the experimental situation the three bands were provided by separate lamps, each with a band-pass filter. The band center wavelengths identified by Thornton are at 80 nm intervals, and three types of 50 mm diameter, 40 nm band pass filters were obtained.

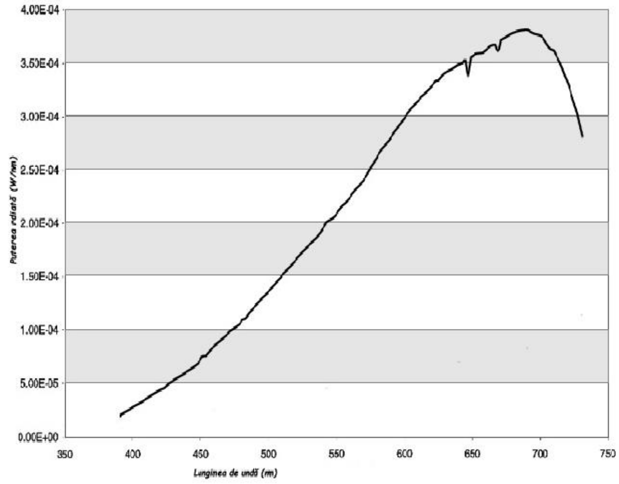

Fig. 1 Spectral power distribution for MR lamp, 2850 K

The 450 nm filter was available as a stock item, but the 530 nm and 610 nm filters were custom items. The filters were mounted in compact industrial luminaire housings fitted with 50 watt MR lamps. Because of the low radiant power from these lamps at short visible wavelengths, it was necessary to use two 450 nm sources. Figura 2 the spectral power distribution for these lamp and filter combinations with their outputs balanced to match the CCT of the source shown in figura 1. The difference in the SPD curves is strikingly obvious: not only are the end parts of the visible spectrum missing, but also there are two deep notches in the curve. Data for the MR and the three-band sources are given in table 1, from which it can be seen that the radiant luminous efficacy for the three-band source is 70% higher than that for the MR lamp. This result means that at equal illuminances (lux), the three-band source will produce 41% less irradiance (W/m2).

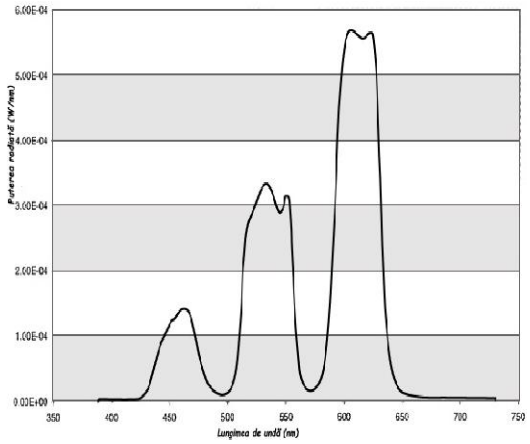

Fig. 2. Spectral power distribution for three-band source, 2850 K

The process of adjusting the balance of the three wave bands of the experimental source was tedious and time consuming. However, the experimental procedure required the three-band source to be dimmable, which created a problem: how to vary the output of the source while maintaining the balance of the wave bands. The problem was solved by a feedback device that was developed specially for this experiment. Each lamp housing was fitted with a light sensor directed toward the lamp. The sensors were connected to the feedback device, a custom electronic circuit that continually monitored the outputs of the lamps and maintained them in constant ratios. The control operated by the subject changed the output of the mid-wave-band lamp, and the feedback device made instantaneous proportional changes to the lamp outputs for the other two wave bands. By operating a switch outside the test room, the experimenter selected whether the subject's control operated the three-band source or the MR lamp, so that the subject was given no obvious indication of which type of light source was in use. The first phase of the experiment was completed using low CCT (approximately 2850 K) sources. For the second phase, the regular MR lamps were replaced with 12 volt, 50 watt “SoLux” MR lamps, which were dimmed to provide 50 lux at approximately 4200 K. Figura 3 shows the spectral power distribution and the loss of long-wavelength power to achieve the higher CCT is apparent. The three-band source was adjusted to match this CCT, and the spectral power distribution is shown in f. Data for these sources are also shown in table 1, and for this higher color temperature the radiant luminous efficacy for the three-band source is 46% higher than for the MR lamp. The main reason this difference is less than for the low color temperature case is that the radiant luminous efficacy of the MR lamp is higher. However, this property does not result because it is a more efficient lamp, but because less radiant power is emitted at the long-wavelength end of the visible spectrum, where the luminous efficiency is very low.

Table 1. Data for the Two Light Source Types at Low and Intermediate Correlated Color Temperatures in the Test Situation

	Low CCT		Intermediate CCT	
	MR	**3-band**	**MR**	**3-band**
Correlated color temperature (K)	2857	2856	4185	4197
Chromaticities:				
x	0.4492	0.4487	0.3766	0.3761
y	0.4107	0.4098	0.3885	0.3884
Radiant luminous efficacy				
(lm/W(r)	224	380	252	367

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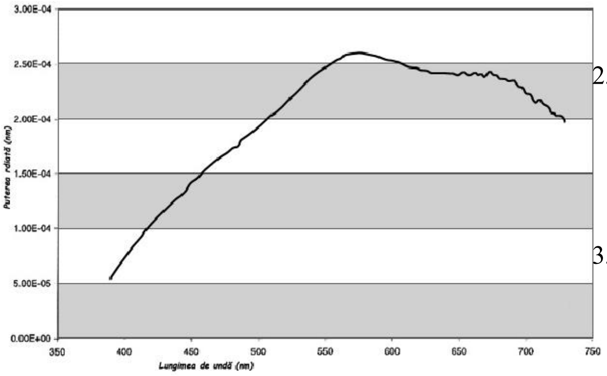

Fig. 3 Spectral power distribution for MR lamp, 4200 K

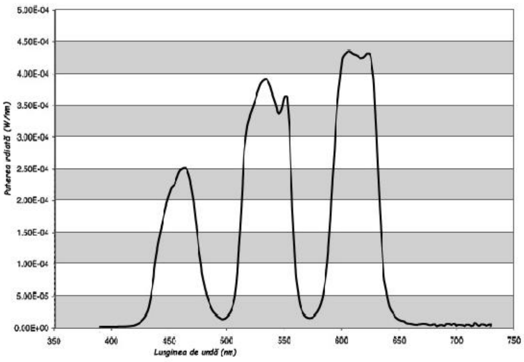

Fig. 4 Spectral power distribution for three-band source, 4200 K

CONCLUSIONS

Three main conclusions emerge:

1. When instructed to adjust for equality of appearance, the subjects set for equality of illuminance. For this condition, the irradiance of the artworks was significantly less for the three-band source than for either of the MR lamps.
2. At equal illuminances and color temperatures, subjects were conscious of differences of appearance between the three-band source and the MR lamps. Generally, they reported the difference to be slight, and their comments did not discriminate against the three-band source.
3. A practical light source for museums could be developed that would have the potential to equal the visual satisfaction provided by incandescent lamps at equal illuminances, while exposing exhibits to significantly less irradiance. This light source would have the effect of reducing the rate of degradation of museum objects on display.

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