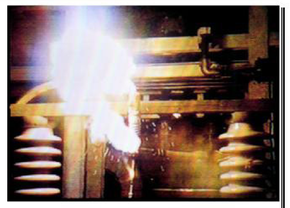
Specifying an Eye Protector for Electrical Utility Workers

University of Waterloo School of Optometry

B. Ralph Chou and Jeffery K. Hovis

Centre for Vision and Ophthalmic Standards, School of Optometry, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1

Introduction



Electrical utility workers have unique visual and ocular protection requirements that need to be addressed in designing protective eyewear.

These specific concerns are due to the hazards from electric arcs and the colour vision demands of identifying wire colours, colour coding on diagrams and indicator light colours.

The Hazards

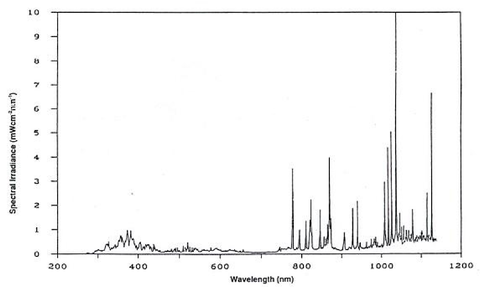


Figure 1. Emission spectrum produced by a 340 A 16 to 17 kV electric arc

- **Ultraviolet Radiation: No Additional Hazard.**

  Total UVB exposure for the brightest 500 ms flash was 0.0015 J-cm^{-2}. This value is a factor of 16 below the threshold exposure for UVB corneal damage of 0.025 J-cm^{2} (Pitts 1993). UVC and UVA radiation levels were insignificant.

- **Foreign Bodies:**

  Small, high-speed droplets of molten metal produced by the arc are a significant impact hazard to the eye.

- **Visible Light Hazard:**

  The visible radiant exposure is well below the threshold for ocular damage (Pitts 1993).

  However, the light intensity (producing approximately 16,000 lux at the worker's eye) is bright enough to cause flash blindness. Impaired vision can last up to 1.0 minute in a relatively dark environment, but only 10 sec in light levels equivalent to room illumination. (Metcalf & Horn 1958)

- **Infrared radiation: Not at hazardous levels.**

  The maximum infrared exposure of 11 J/cm^2 was well below the damage thresholds for both the cornea (6000 J/cm^2) and crystalline lens (4000 J/cm^2) (Pitts 1993).

The eyewear requirements

- **UV Radiation Protection: from solar UV radiation.**

  Any polycarbonate lens with an UV inhibitor would provide adequate protection. These lenses cut off optical radiation below 400 nm.

- **Protection from foreign bodies.**

  Polycarbonate industrial eye protectors with side protection that meet CSA high speed impact and flame resistance requirements are needed to prevent eye injuries from the hot metal droplets.

- **Tinted lenses: Primarily for reduction of glare from the sun.**

  In order to ensure almost instantaneous recovery of the vision after the flash, a Shade 7 or 8 welding filter (approximately 0.2% transmittance) is required. This is too dark for practical use. Flip-ups are a possibility, but looking away would also reduce flash blindness.

  To reduce glare from the sun, transmittances between 10% and 25% provide adequate protection. We recommended a luminous transmittance target value of 20%. A clear lens should have a luminous transmittance of at least 85% to ensure adequate retinal illuminance at night.

- **Tint Colour: Grey**

  Lens transmittance tolerances based on utility workers' colour vision demands have not been established to our knowledge. The reasons for the lack of this information include the cost involved, since the objects and viewing conditions are so varied. Nevertheless, one can ensure that colour perception is unaffected by using a tint that transmits all wavelengths of light equally.

- **But how close to being equal?**

  Figure 2 shows the proposed limits in the CIE 1931 colour diagram for colour shifts of white light. These limits are based on Ohta and Wyzecki's (1976) results for a daylight simulator and represent $\pm 0.15 * \tau$, where τ is mean transmittance value for wavelengths in the visible spectrum.

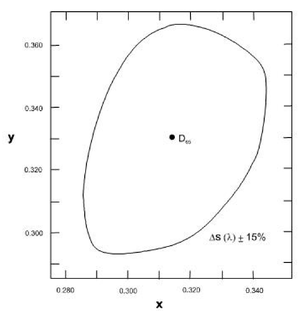


Figure 2. Tolerances for the colour shift of daylight D65 that are produced by tinted lenses

There is also a separate standard for the red signal light visibility. The red visibility factor is

$$\frac{\textit{Luminous Transmittance of Red Signal}}{\textit{Luminance Transmittance of Daylight}}$$

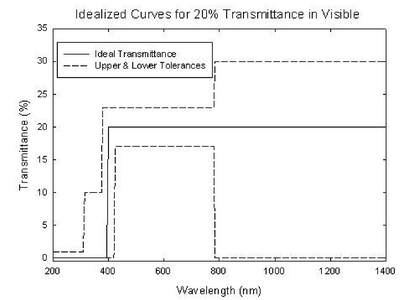
- **Infrared radiation protection: none required**

  However, if the manufacturer is claiming that the lens protects from infrared radiation, most standards organizations require that

$$\textit{Mean Infrared Transmittance} \leq 1.5 \cdot \textit{Luminous Transmittance}$$

Conclusions: the ideal sunlens

Transmittance curve of ideal sunlens and the tolerances



Transmittance curve of a clear lens would be similar in the UV region with a minimum transmittance of 85% in the visible region and no greater than 85% in the infrared region.

Acknowledgements

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References

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