

**PHOTOMETRIC GUIDELINES FOR INSTRUMENT PANEL DISPLAYS
THAT ACCOMMODATE OLDER DRIVERS**

1. Scope—Physical parameters that influence the legibility of an instrument panel display include letter/graphic size, the luminance and color difference between graphics and background, the observer's luminance adaptation level, and the level of glare present. Several aspects of visual functioning deteriorate as part of the normal aging process. These include a reduction in luminance and color contrast sensitivity, an increase in sensitivity to glare, a reduction in visual accommodation capacity, and a reduction in the sensitivity to light. This SAE Information Report provides introductory information that should be considered when setting photometric guidelines for instrument panel displays that are designed to accommodate the older driver. More detailed information is provided in Section 2 of this document.

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein.

1. Wyszecki, G., and Stiles, W.S. (1982), *Color Science: Concepts and Methods, Quantitative Data and Formula* (2nd edition), New York: John Wiley and Sons.
2. Poynter, D. (1988), "The Effects of Aging on Perception of Visual Displays," SAE 881754, Warrendale, PA.
3. Poynter, D. (1991), "Contrast Sensitivity and English Letter Recognition," *Proceedings of the 1991 Human Factors Society Annual Meeting*, September 2–6, San Francisco, CA.
4. Blackwell, H.R. (1959), "Specification of interior illumination levels," *Journal of the Illuminating Engineering Society*, June, 317–353
5. Blackwell, O.M., and Blackwell, H.R. (1971), "Visual performance data for 156 normal observers of various ages," *Journal of the Illuminating Engineering Society*, October, 3–13.
6. Blackwell, O.M., and Blackwell, H.R. (1980), "Individual responses to lighting parameters for a population of 235 observers of varying ages," *Journal of the Illuminating Engineering Society*, July, 205–232.
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8. Boynton, R.M., Rinalducci, E.J., and Sternheim, C. (1969), "Visibility losses produced by transient adaptational changes in the range from 0.4 to 4000 footlamberts," *Illuminating Engineering*, 217–227.

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9. Osaka, N. (1985, July), "The effects of VDU color on visual fatigue in the fovea and periphery of the visual field," *Displays*, 138–140.
10. Matthews, M.L. (1987), "The influence of colour on CRT reading performance and subjective comfort under operational conditions," *Applied Ergonomics*, 18.4, 323–328.
11. Galer, M.D., and Simmonds, G.R.W. (1985), "The lighting of car instrument panels—drivers' responses to five colours," SAE 850328, Warrendale, PA.
12. Uchikawa, K., Uchikawa, H., and Kaiser, P.K. (1984), "Luminance and saturation of equally bright colors," *Color Research and Application*, 9(1), 5–14.
13. Poynter, D. (1988), "Variability in brightness matching of colored lights," *Human Factors*, 30(2), 143–151.

2.2 Terminology—The spectral power distribution of a light source can be described as a location in any one of several three-dimensional color spaces [1].¹ In most of these spaces, two of the dimensions correspond to the perceived color of the light. The third dimension (luminance) corresponds to the perceived intensity of the light. The luminance dimension can be thought of as representing perceptual brightness, although other factors aside from luminance can affect how bright a light source appears to be (e.g., the size of the source).

"*Luminance Contrast*" is a measure of the difference between the luminance of a display letter/graphic and the luminance of its spatially contiguous background. There are several commonly used indices of luminance contrast. The one used in this document is as in Equation 1:

$$\frac{L_{\max} - L_{\min}}{L_{\min}} \quad (\text{Eq. 1})$$

where:

$L_{\max}$ and $L_{\min}$ are the larger and smaller of stimulus and background luminance, respectively.

The term "*Color Contrast*" refers to the difference in color between the letter/graphic and its background. There are several ways to quantify color contrast. One of the most common indices is the distance in color space between the coordinates for the letter/graphic and the coordinates for the background. In this document, luminance contrast and color contrast are considered separately; therefore the term color contrast refers to a two-dimensional distance across a plane in color space perpendicular to the luminance dimension.

Finally, the term "*Adaptation Luminance*" refers to the level of light that the driver's visual system is adapted to. In an automobile, for example, the adaptation luminance will most often be the average luminance of the driver's field of view through the windshield. During daytime driving, the adaptation luminance will typically be many times higher than the luminance of displays in the interior of the automobile.

3. Photometric Guidelines for IP Displays

3.1 Luminance Contrast—The minimum value of luminance contrast required to ensure display legibility is not a constant. It depends upon the amount of color contrast present, the size of letters/graphics, display luminance, adaptation luminance, driver age, and other contextual factors. For example, the studies of references [2,3] show that changing the height of display letters from 0.15 degrees to 0.3 degrees can reduce contrast requirements by a factor of 3. Contrast requirements for relatively dark ambient conditions (less than 0.1 cd/m²) can be 20 times greater than contrast requirements for moderate to bright conditions (greater than 50 cd/m²) [4,5,6]. Adding a color difference between letters and background also has a strong impact on minimum luminance contrast. For example, a distance between letters and background of 0.10 in the 1976 u^*v^* color plane can reduce luminance contrast requirements to 0.0. The effect of color contrast on legibility depends upon letter size and display luminance [3,7]. Color contrast improves legibility the most when letters/graphics are relatively large and display luminance is relatively high.

1. The brackets represent the references.