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(R)

Instrument and Cockpit Illumination for General Aviation Aircraft

1. SCOPE:

This document establishes acceptable design criteria for instrument and cockpit illumination for general aviation aircraft.

2. REFERENCES:

The Human Engineering Guide to Equipment Design, DOD, US Government Printing office, 1972

Human Engineering Guide for Equipment Designers, Woodson, Conover, University of California Press, Berkeley, 1985

IES Lighting Handbook, Illumination Engineering Society, 8th Ed., 1993

ARP4256, Design Objectives for LCDs for Part 25 (Transport) Aircraft

Walsh, J. W. T., Photometry, Dover, NY 1965

3. DEFINITIONS:

3.1 Footlambert:

A measure of the luminance of a surface which emits or reflects light. A perfectly reflecting surface illuminated by 1 fc has a luminance of 1 fL (i.e., Footlamberts = footcandles x reflectance factor of surface, Footlamberts (fL) x 1.076 = millilamberts (mL), Millilamberts x 0.929 = fL).

3.2 Footcandle:

A unit of measure of illumination. 1 fc is the illumination on a surface 1 ft from a uniform point source of 1 candela (cd).

3.3 Reflectance:

The ratio of the amount of light reflected from a surface to the amount of light incident on a surface. Usually this is given as a percentage.

3.4 $$\% \text{ Reflectance} = \frac{\text{Light reflected from a surface}}{\text{Light incident on a surface}} \times 100 \quad \text{(Eq. 1)}$$

If the surface were a perfect white reflector, this would be 100%. For example, white paint will reflect about 80 to 95% of the light that hits it. Medium gray has a reflectance of around 50%, dark blue about 8%.

3.5 Contrast Ratio:

The ratio of the amount of light coming from an object to the amount of light from the area surrounding the object.

$$\text{Contrast ratio} = \frac{\text{Amount of light from object}}{\text{Amount of light from surrounding area}} \quad \text{(Eq. 2)}$$

Example: If we put a white instrument (reflectance 90%) on a dark blue panel (reflectance 8%) we will get a 90:8 (11:1) reflectance ratio. The same instrument on a dark gray panel (reflectance 30%) would have a 3:1 contrast ratio.

Note that this ratio could work with an internally illuminated instrument or a flood-lighted panel.

4. METHODS OF LIGHTING:

Any lighting method which meets the recommendations should be considered satisfactory. White lighting should be considered the basic illumination. In special applications where maintenance of maximum dark adaptation is necessary, red lighting may be used.

5. RECOMMENDATIONS:

5.1 The desired system for general aviation aircraft instrument panel and cockpit lighting should furnish light of adequate intensity and distribution under all conditions of external illumination so that the crew may read instrumentation, placards, check lists, manuals, maps, instrument color coding, and distinguish controls without undue interference with their vision outside of the aircraft.

5.2 General:

5.2.1 If different colored lighting systems are incorporated, they should be separately controlled.

5.2.2 Whatever method of lighting is used, it should provide for illuminating not only instruments and indicators, but also switches, placards, and knobs. Light assemblies should not interfere with a clear view of the instrument face. The designer should take into consideration the angle of the view of the user(s) of the instrument.

Light distribution and shielding should be accomplished to eliminate or minimize direct or indirect glare and reflection from instrument faces, panels, and windshields. Shadow blanketing of the panel and its components by controls, accessories, or the pilot's body should be avoided.

5.2.3 Lighting shall not interfere with legibility of markings for daylight operation.

5.3 Arrangements:

5.3.1 It is recommended that the instrument panel and other areas be lighted in sections corresponding to the intended use of the aircraft. For single-pilot aircraft the light may be controlled by a single intensity control. For two-pilot aircraft the panel should be lighted in at least two flight sections, with separate intensity controls covering duplicated instruments. If a third section is used to include shared instruments and indicators, it should have its own intensity control. If flood lighting is used, the previously mentioned principles should be followed.

5.3.2 Specific effort should be made to provide even illumination on the face of each instrument or indicator and to balance illumination among the instruments. The light reflected from an instrument as compared to the light reflected from the instrument panel should not exceed a 7:1 ratio. For example, if the light reflected from an instrument was 7 fL, the light reflected from the panel surrounding the instrument should not be less than 1 fL. Note 5.7.1. See Section 3, Definitions.

5.3.3 Aircraft should be provided with adequate light traps and curtains to isolate the pilots from strong light coming from the passenger areas or provide for ultimate control of the light by the pilot.

5.3.4 Each pilot should be provided with a map-reading light, controlled by an intensity control. This light should provide diffused illumination for an area adequate for chart reading without interfering with other cockpit activities.

5.3.5 To provide an emergency lighting system, a source of white light for the pilot(s) should be supplied. (A flashlight or other independent means is acceptable.)

5.4 Controls:

5.4.1 The intensity controls for operating the cockpit and panel lights should be of a continuous type. If rotary controls are used, they should be full "off" in the extreme counter-clockwise position, proceeding clockwise from extinction to the approximate midpoint of its physical travel where the specified brightness values listed in 5.5 will be met. Thereafter, proceeding to the full clockwise position of travel, at which point approximately three times the specified midpoint values will be attained. Brightness values for the initial, midpoint, and terminal control positions should be proportional per the above for nonrotary controls as well.

5.4.2 Location: Intensity controls should be located for convenient manipulation by the person utilizing the display that is illuminated.

5.5 Brightness Values:

5.5.1 White Light:

5.5.1.1 The intensity of light supplied to the pilots' instrument panels should be such as to produce a luminance of 5 fL from dial markings having a reflectance of 75%, when the intensity control is in the approximate physical midposition.

5.5.1.2 The intensity of map reading lights should be such as to produce a minimum brightness measured at the pilot's lap, of 5 fL, on a surface having a reflectance of 30%, with the intensity control in the approximate physical midposition.

5.5.1.3 Fixed intensity lights should produce a luminance of 6 fL on a surface having a reflectance of 30%.

5.5.1.4 Side console lighting should produce a luminance of 6 fL on a surface having a reflectance of 30% with the intensity control in the approximate physical midposition.

5.5.1.5 Intensity measurements should be made with any standard illumination measuring instrument which takes into account the photopic spectral sensitivity of the human eye. Tolerance on all above measurements may be ±10%.

5.5.2 Where red lighting is used, the standards of AS264D should be followed.

5.6 Distribution:

5.6.1 Instrument Panels:

5.6.1.1 The distribution of light on each instrument should be such that all markings can be read, without the presence of shadows or light graduation greater than 3:1.

5.6.1.2 If, in a group of instruments on a panel, one or more of them appear to be better illuminated than others because of design or marking differences, an effort should be made to equalize the apparent luminance.

5.6.2 Back-Lit Panels: Back lighting through etched or marked panels should have such distribution that any marking located in any position on the panel will appear to be of the same intensity. The maximum brightness difference should be in the order of 3:1 from actual measurements. In no case should the available luminance be below 1 fL.

5.7 General Lighting:

5.7.1 Instrument Panels: To avoid visual illusions it is necessary to have a slight amount of light illuminating the instrument panel itself to avoid the effect of the instruments standing out by themselves. This luminance should be at least 0.03 fL.

5.7.2 A separate source of controlled white light should be provided for the control pedestal so that, with the intensity control in its approximate physical midposition, 12 fL will be obtained at the pedestal surface.

5.7.3 Where post lighting or other semi-direct lighting is employed to light one or more instruments, specific effort should be made to insure that the best illumination of the instrument scale occur at ranges of interest to the pilot.

5.8 Brightness Ratios:

5.8.1 Reading of an instrument dial necessitates close attention. Therefore, high contrast between the details and the work field should be required as well as low contrast between the brightness of the work field and its surroundings. For a pilot, the dial markings, indicators, and pointers constitute the details; the whole instrument face is the work field; and everything else may be considered as the surroundings.

5.8.2 Considering the above, the following tables of values (Tables 1 and 2) are presented as adequate: