SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

SAE ARP582

REV. C

Issued 1961-08
Reaffirmed 1991-04
Revised 2001-06
Noncurrent 2006-08

Superseding ARP582B

Lighting, Integral, For Aircraft Instruments: Criteria for Design of Red Incandescent Lighted Instruments

RATIONALE

This ARP has been determined to be noncurrent because no new aircraft use red incandescent instrument lighting. While there are many older aircraft that still use them, with a noncurrency status, the document is still an available reference for older aircraft.

NONCURRENT NOTICE

This specification has been declared "NONCURRENT" as of August 2006. It is recommended, therefore, that this document not be specified for new designs.

Each of these "NONCURRENT" documents is available from SAE.

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1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) covers the general requirements and test procedures for illuminating systems for integrally lighted aircraft instruments in order to provide (a) uniformity of illumination within each instrument, (b) legibility of instrument presentation under daylight or integral light, and (c) uniformity of illumination between instrument displays.

1.1 Purpose:

The purpose of this document is to recommend certain basic considerations and criteria which the designer should observe when designing a system of red integral lighting for aircraft instruments.

2. REFERENCES:

See Appendix A - Bibliography.

3. RECOMMENDATIONS:

It is recognized that several techniques are applicable to integral lighting of instruments. Typical examples are edge lighting, back lighting, direct lighting, and wedge lighting. The considerations and criteria included herein are specified in sufficiently broad terms to permit the designer to utilize the technique most suited to the problem at hand, provided it meets the requirements of the applicable instrument specification, and takes into consideration also the environmental conditions, power available, space available, weight, cost, etc. For various suggestions, the designer is referred to Appendix I of ARP798, Design Criteria for White Incandescent Lighted Aerospace Instruments.

3.1 Design and Construction:

3.1.1 Materials: The instrument lighting system should be of a type of material and construction to withstand the service, functional, and environmental conditions specified by the applicable instrument specification, without degradation of the lighting requirements. Lens design should include reflection reducing coatings for the instrument cover glass. Cognizance should be taken of the fact that lighting systems generally run considerably hotter than the environments in which the instrument is operating.

3.1.2 Lighting System: The lighting system should be so designed that the light sources are contained within the instrument enclosure. The lighting system should not interfere with the visibility of any portion of the instrument display as outlined in the applicable instrument specification. No marking should depend solely on one incandescent lamp for its illumination. The lighting system should last the service life of the instrument and should in no way interfere with the correct operation of the instrument. Additional lighting system design review should include consideration arising from mixing different lighting technologies on the same dimmer controller. This includes voltage differences and dimming curves.

3.1.3 Lamps: A wide range of tungsten filament lamps conforming to MS24367, MS24515, MS90451, and MS90452 are available to the designers. When the instrument filling medium consists of any portion of helium, only MS27569, MS27570-1191AS15, MS27570-8515AS15, MS27571-6808AS15 or MS27571-6809AS15 lamps shall be used. Where practicable, the lamps should be made on the basis of the lamps with the longest life that will give the required illumination. In addition to the preceding MS lamps, it shall be permissible to use MS24367-713AS15, MS24367-715AS15, MS24515-714AS15, MS24515-718AS15, MS25237-328AS10 lamps if helium is not used in the filling medium or if the instrument is not hermetically sealed. If the lamps are to be replaceable, it is recommended that MS25237-328 (for 5-V operation) or MS25237-327 (for 28-V operation) can be used (or the MIL-L-6363/8 replacement). In these cases, the red filters should be contained within the instrument so that lamps meeting these specifications may be replaced at will. Furthermore, all lamps in the lighting system shall be of the same type.

3.1.4 Lamp Location: Lamps may be either accessible from the outside of the instrument or sealed within the instrument enclosure. Where practicable, the lamps should be removable without opening the instrument case. When lamps are removable, the replacement units may be located anywhere on the instrument case. The location of the lamps should not result in protrusions from the instrument case, which would interfere with the removal of the instrument from its mounting provisions on the panel. Inflight replacement of lamps is not intended. At least two incandescent lamps should be used to illuminate the instrument. Where the applicable instrument specification requires hermetic sealing, the lamps need not be contained within the seal or may be completely enclosed within the sealed instrument.

3.1.5 Lamp Circuit: The lamp circuit should preferably be designed to operate from a 5-V power system. All lamps should be connected in parallel. The lamp circuit should terminate in two electrically independent pins of the instrument connector. One of the terminals may be case grounded at the option of the instrument designer except where it would be harmful to the correct operation of the instrument. Resistors should not normally be used within the instrument to change the voltage applied to the lamps from that applied to the lighting terminals of the electrical connectors unless the instrument design requires the use of smaller 5-V lamps and the instrument specification requires 28-V lighting. The use of a resistor should be cleared with the procuring activity.

3.1.6 Dielectric Strength: The insulation should withstand without evidence of damage the application of a sinusoidal voltage at a commercial frequency between all electrical circuits connected together and the metal case for a period of 5 s. The rms value of the sinusoidal voltage applied should be 500 V plus twice the lamp circuit design voltage for 1 min, except for hermetically sealed helium filled instruments, where the test voltage should be 200 V rms.

3.1.7 Electrical Connector: Unless otherwise specified by the procuring activity, the electrical circuit for the lighting system should terminate in two electrically independent pins in the electrical connector used for other electrical terminals to the indicator. In the event the instrument does not require an electrical connector except for the lighting circuit, a connector having a minimum of two electrically independent pins should be provided. A suitable cap should be provided to protect the connector during shipment and storage. Unless otherwise specified by the procuring activity, the connector should be located on the back of the instrument case. A mating connector plug assembly with approximately 3 ft of wire attached to the lighting terminals should be furnished for qualification or preproduction test units.

3.1.8 Color: Red lighting required is generally "Aviation Red" as required by MIL-L-25467. In instruments this color can be obtained by various means: a red filter can be inserted in the path of the light (fixed filters, boots slipped over the lamps, etc.) or lamps with colored glass or color coated to emit the proper color can be used. It is recommended that when lamps are replaceable, fixed filters that are not part of the lamp be used. Filters should be heat resistant and must not change shape or color under the most severe heat conditions to be encountered.

3.1.9 Brightness: When 5 V ± 2% (design voltage ± 2% for other than 5-V circuits) is applied to the lighting terminals, the brightness of the presentation should conform to Table 1. For any display the brightness of the pointers and lubber lines should always be brighter than the display markings but should not exceed 1.8 fL.

3.1.9.1 Special Considerations: When markings or display elements are used, which are colored red (munsel) (Color Designation 5 Red 4/14) under daylight illumination, their brightness, when illuminated by the red lighting system of the instrument, should in general be consistent with the surrounding red lighted markings or display elements, except in the case of warning elements, and should have a brightness of 1.5 to 3.0 fL at rated voltage. All brightness readings will decrease as voltage is decreased.

TABLE 1 - Brightness (Redlight) of Markings, Display Elements and Background Areas

Daylight Color	Brightness (fL) White	Brightness (fL) Grey	Brightness (fL) Black
White (37875) Markings or White (37875) Display Elements and Grey ( ) Background	1.0 ± 0.5	0.06 ± 0.03	
White (37875) Markings or White (37875) Display elements and Black (37038) Background	1.0 ± 0.5		0.02 - 0.10
Black (37038) Markings or Black (37038) Display Elements and Grey ( ) Background		0.6 ± 0.3	0.01 Maximum
Black (37038) Markings and White (37875) Display Elements and Grey ( ) Background	1.0 ± 0.5	0.3 ± 0.2	0.05 Maximum

Numerical designations in parenthesis refer to colors listed in Federal Standard No. 595. Tighter tolerances may be desirable to secure better uniformity between various instruments. It is suggested that while individual readings be as in Table 1, the average of all readings fall in the upper range of the tolerance.

3.1.9.2 Brightness Balance: It is desirable that the relative importance of different elements of a presentation be considered when designing a lighting system, in order that those elements of greater importance will have relatively greater brightness within the specified brightness range. Where relatively large illuminated areas are adjacent to small illuminated areas, the small areas should be of greater brightness for apparent intensity balance. For average brightness readings of white markings, individual brightness values shall be between 1.0 fL ± 0.5 fL, but the average brightness of the light should be 1.00 fL ± 0.20 fL.

3.1.10 Stray Light: The lighting system should be so housed as to prevent leakage of stray light and to shield from direct view all lamp filaments. When a white sheet of paper is placed perpendicular to the coverglass and on any line parallel to the horizontal center line of the instrument, the brightness of any point looking down on the paper should not exceed 1.50 fL and on any point looking up on the paper should not exceed 0.20 fL. The sheet of white paper used in the above measurements should be neutral, diffusing, and have a reflectance of 85% ± 5%.

3.1.11 Knobs: Unless otherwise specified in the applicable instrument specification, all indicia associated with the instrument knob positions should be illuminated. The brightness range should be as specified herein.

3.1.12 Indicia: The presentation may be any combination of white, black, grey, or red as specified in the applicable instrument specification. Unless otherwise specified in the applicable instrument specification, the colors should conform to Table 1.

3.1.13 Contrast: Daylight contrast between the white and black portions of the indicator presentation should be 12 or greater. Contrast between the white and grey or the grey and black portions of the indicator display should be 5 or greater. Contrast "C" is defined as:

$$C = \frac{B_2 - B_1}{B_1} \qquad \text{(Eq. 1)}$$

Where:

B_2 = Brightness of the grey or white portions of the instrument display
B_1 = Brightness of the black or grey portions of the instrument display

Contrast measurements should be made as per 4.2.6.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Test Conditions:

4.1.1 Atmospheric Conditions: Unless otherwise specified, tests required by this specification should be made at atmospheric pressure of 28 to 32 in Hg, a temperature of 25 °C ± 10 °C, and a relative humidity of 80% or less.

4.1.2 Environmental Conditions: Wherever possible, the tests described in 4.2 should be performed after the environmental tests required by the applicable instrument specification.

4.2 Test Methods:

4.2.1 Examination of Product: The lighting system should be examined carefully to determine conformance to those requirements of Section 3 that can be checked visually.

4.2.1.1 Indicia: The instrument should be checked visually to assure conformance with the requirements of 3.1.12.

4.2.1.2 Dial Visibility: The instrument should be checked to assure that the lighting system does not interfere with the visibility of any portion of the instrument display as outlined in the applicable instrument specification.

4.2.2 Operation: The lighting system should be energized with 5 V or the applicable voltage and examined to ascertain that all lamps function properly.

4.2.3 Life: The lighting system should be subjected to a life test with 5 V ± 2% (or applicable voltage ± 2%) applied to the lighting terminals. The duration of the life tests should be 1000 h or for a period equal to the life test time required by the applicable instrument specification. Wherever possible, the lighting system life test should be performed concurrently with the life test of the instrument. During the life test of the instrument lighting system, the power supplied to the lighting circuit should be interrupted every 57 min for a period of 3 min.

4.2.4 Lighting Tests:

4.2.4.1 Instrument Calibration: With an approved photometer (or one that is calibrated in accordance with the manufacturer's instructions and NIST traceable), the calibration shall be accomplished using a brightness source or reference within the range of the test. When a photometer is used as part of the test equipment, the following calibrations and checks shall be verified within a year prior to taking a measurement:

- Measure spot size of 0.004 to 0.007 in as the minimum.
- Having a focus no less than 4 in from the front of the lens.
- Minimum full scale sensitivity to 0.1 fL.
- A stability of ±2% combined zero and sensitivity drift over an 8 h period after a 15 min warm-up.
- Having a polarization error of less than 1%.
- Being able to locate a spot being measured with maximum error or 0.002 in.
- Having a readout with a resolution of no less than 0.1% of full scale.
- For colorimetric trim, a maximum correction IPL Red light (3215 Red versus 2856 Kelvin): of ±10% of filter transmittance.
- For colorimetric trim, a 4-filter tristimulus colorimetric capability with a maximum error for any Blackbody (lamp) color temperature ±0.005 x and y from 1800 to 2856 Kelvins when calibrated at 2856 degrees Kelvin for an ambient temperature excursion of 70 °F ± 5 °F.

4.2.4.2 Color Measurement: Apply 5 V ± 2% (or applicable voltage ±2%) to the lighting terminals. All measurements shall be made in completely dark surroundings. With a photometer that has been calibrated in accordance to 4.2.4.1, focus on a red portion of the illuminated indicator. The value should conform to Table 1, 3.1.9.

4.2.4.3 Brightness Measurements: Calibrate the photometer with a brightness source. Focus the photometer on a lighted portion of the indicator and take a reading (R_1). Insert an NBS filter No. 3114 in the optical path between the instrument and the photometer without changing focus and take a reading (R_2). Compute the ratio of (R_2) divided by (R_1). Enter this ratio into the CCF-3114 graph on the "X" coordinate and determine the value "Y." The true brightness of the indicator is given by multiplying (R_1) by "Y." The values should conform to Table 1, 3.1.9.

4.2.5 Stray Light: Stray alight should be checked to determine that the instrument meets the requirements of 3.1.8.