SAE Aerospace
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AEROSPACE RECOMMENDED PRACTICE

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Night Vision Imaging System (NVIS) Compatible Illuminated Pushbutton Switches and Indicators

RATIONALE

Warning, caution and advisory push-button switches and indicators are considered by pilots to be one of the most important items in the aircraft crew station. Due to the different colors, these push-button switches and indicators are particularly difficult in an NVG green-lighted compatible crew station. This specific technology, which is utilized to deal with the design of these devices is covered in this document.

1. SCOPE:

This SAE Aerospace Recommended Practice (ARP) reviews the basics of NVIS compatibility and discusses the specific illuminated pushbutton switch and indicator requirements for sunlight readability, color, luminance, and NVIS radiance when used in NVIS compatible cockpits.

The recommendations and special considerations set forth in this document are made to give the design engineer a better understanding of MIL-L-85762A NVIS compatibility requirements and to provide information on the visual characteristics of NVIS compatible pushbutton switch and indicator displays.

1.1 Purpose:

The purpose of this document is to recommend the design requirements and considerations which the design engineer should observe when selecting and using NVIS compatible illuminated pushbutton switches and indicators.

NVIS compatible lighting is defined as any lighting whose spectral radiance has been selectively filtered to meet the NVIS radiance and chromaticity requirements of MIL-L-85762A when dimmed to the specified luminance value.

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2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this specification to the extent specified herein.

2.1.1 U.S. Government Publications: Available from the Document Automation and Production Service (DAPS), Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6257, http://assist.daps.dla.mil/quicksearch/.

MIL-L-85762A	Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible
MIL-PRF-22885G	Switches, Push Button, Illuminated, General Specification for
MIL-S-38039B	Systems, Illuminated, Warning, Caution, and Advisory, General Specification for

3. NVIS COMPATIBILITY BASICS:

3.1 Night Vision Imaging System (NVIS):

NVIS are devices that provide aircrew members with the ability to see at night by greatly amplifying outside scenes illuminated by the night sky.

3.1.1 Image Intensifiers: NVIS use third generation (GEN III) image intensifier tubes having a gallium-arsenide photocathode and microchannel plate to produce the amplification necessary to operate in starlight.

3.1.2 Mechanics of NVIS Operation: The night sky irradiates objects with photons which are reflected as photon images. These photon images are focused by the objective lens onto the photocathode which emits electrons in direct proportion to the number of photons striking its surface. These electrons are greatly multiplied by the microchannel plate and are directed onto a phosphor screen where the amplified image is viewed through the ocular lens (see Figure 1).

3.2 Classification:

NVIS compatible lighting requirements are stated based on the type and class NVIS being used.

3.2.1 NVIS Types:

3.2.1.1 Type I: These are direct view image NVIS which display the intensified image on a phosphor screen in the user's direct line of sight.

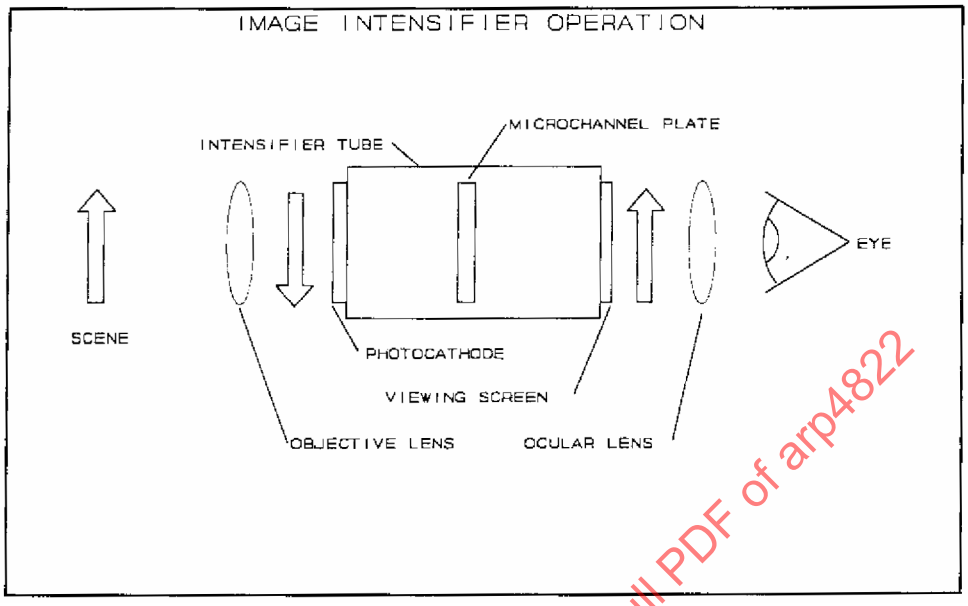

FIGURE 1

3.2.1.2 Type II: These are projected image NVIS which project the intensified image on a see-through medium in the user's line of sight.

3.2.2 NVIS Classes:

3.2.2.1 Class A: Any NVIS utilizing a 625 nm minus blue objective lens filter conforming to the specifications in Figure 2 are Class A. The relative spectral response of the Class A NVIS is shown in Figure 3 and the tabulated values are listed in Table 6 of MIL-L-85762A.

3.2.2.2 Class B: Any NVIS utilizing a 665 nm minus blue objective lens filter conforming to the specifications in Figure 4 are Class B. The relative spectral response curve of the Class B NVIS is shown in Figure 5 and the tabulated values are listed in Table 7 of MIL-L-85762A.

3.3 NVIS Compatible Lighting:

NVIS compatible lighting is lighting which can be seen with the unaided eye without causing interference or degradation of the NVIS intensification capabilities.

3.3.1 NVIS Radiance: NVIS radiance is the amount of energy emitted by a light source that is visible through NVIS and represents the amount of interference produced by the light source.

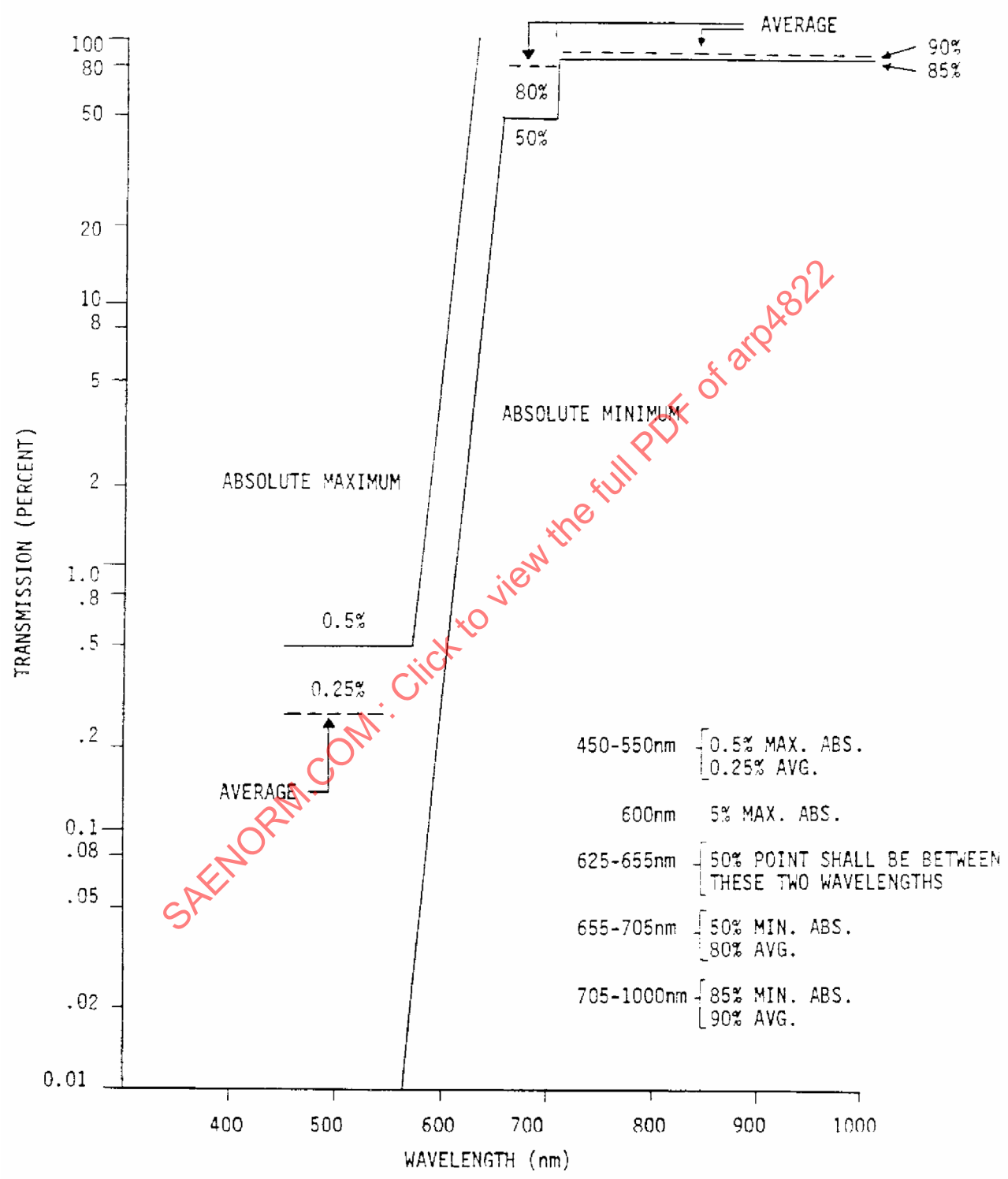

FIGURE 2 - (Class A) 625 nm Minus Blue Filter Specification

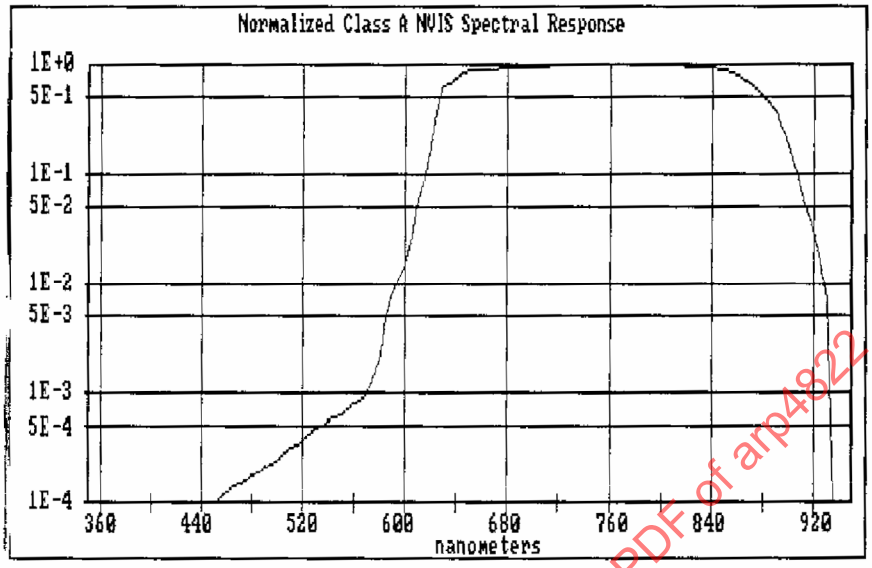

FIGURE 3

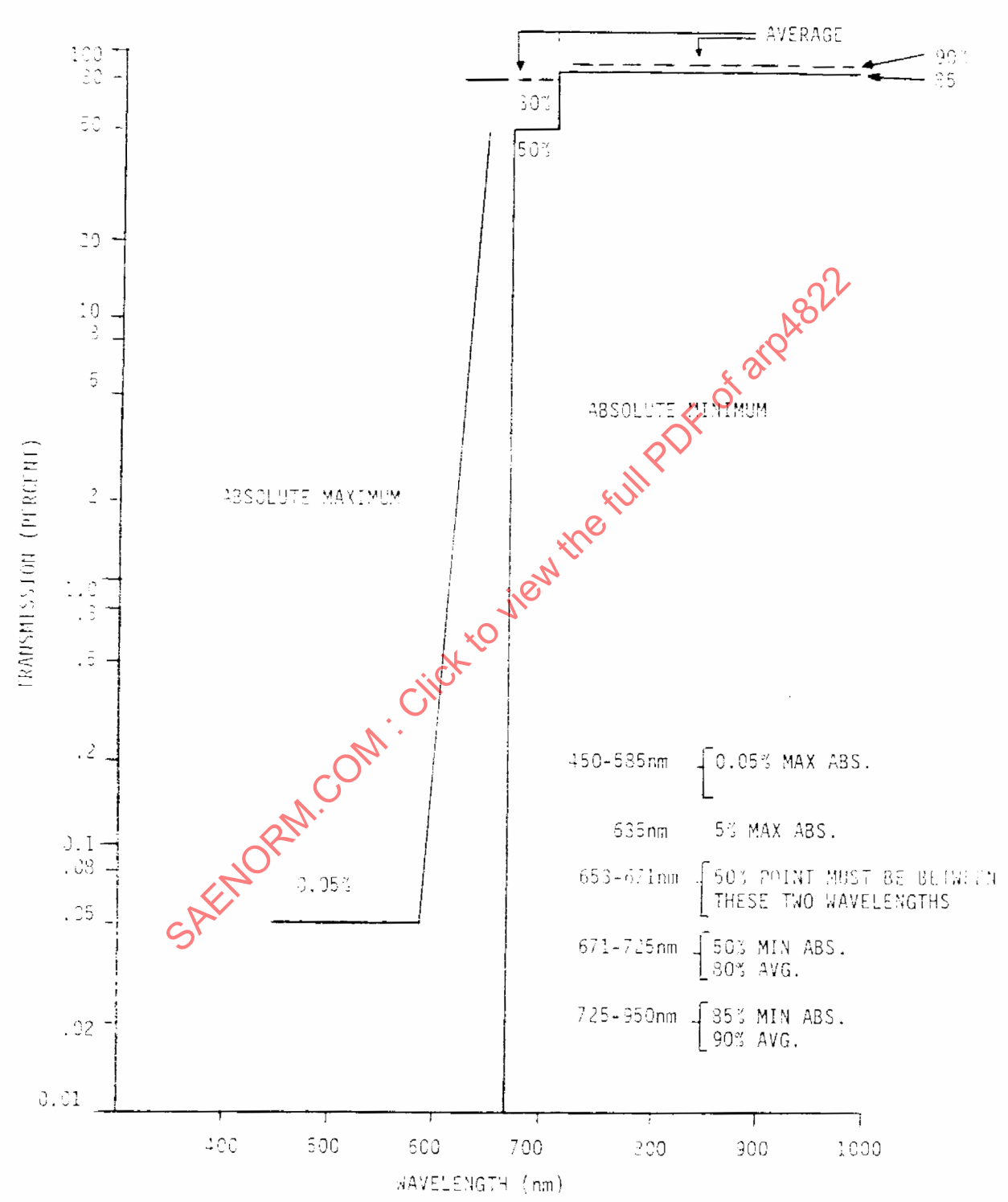

FIGURE 4 - (Class B) 665 nm Minus Blue Filter Specification

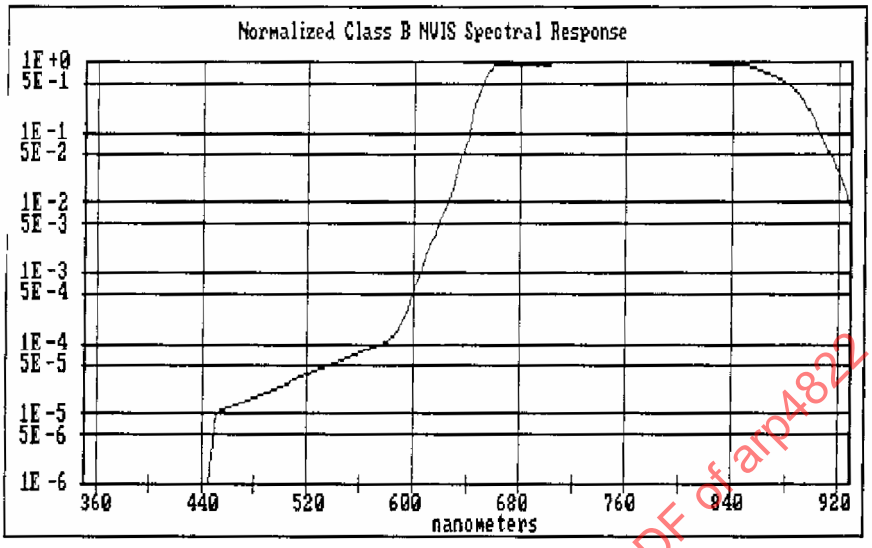

FIGURE 5

3.3.2 Definition of NVIS Radiance: NVIS radiance (NR) is the integral of the curve generated by multiplying the spectral radiance of a light source by the relative spectral response of the Class A or Class B NVIS.

$$NR = G(\lambda)\,\max \int_{450}^{930} G(\lambda)\, SN(\lambda)\, d\lambda \qquad \text{(Eq. 1)}$$

where:

NR = NVIS radiance

$G(\lambda)$ max = 1 mA/W (for the correct units)

$G(\lambda)$ = Relative NVIS response

$N(\lambda)$ = Spectral radiance of lighting component

($W/cm^2*sr*nm$)

$d\lambda$ = 5 nm increments

S = Scaling factor L_R/L_M

where: L_R = Luminance required

L_M = Luminance measured

3.3.3 Definition of Compatible Lighting: A lighting component produces compatible lighting if its NVIS radiance does not exceed a specified maximum when set to produce a specified luminance. For primary cockpit lighting the maximum allowable NVIS radiance is 1.7×10^{-10} when the lighting is set to produce 0.1 fL.

4. RECOMMENDATIONS:

Illuminated pushbutton switches and indicators are used in crew stations as visual signals to provide crew members with vital status information. Functionally, they serve as caution and advisory lights, master caution lights, and warning lights. When these crew stations are required to be compatible with NVIS, the pushbutton switch and indicator displays must meet the lighting requirements of MIL-L-85762A. These compatibility requirements must be strictly observed so as not to compromise the safety of crew members performing tasks while using NVIS.

4.1 Sunlight Readability:

Illuminated pushbutton switches and indicators requiring readability in sunlight must meet the daylight legibility and readability requirements of MIL-L-85762A. Two separate requirements are defined depending on whether or not the display is to be readable in direct reflected specular sunlight.

4.1.1 Specular Sunlight Readability Requirements: Illuminated switches and indicators requiring readability in direct reflected specular sunlight must have a lighted contrast C_L not less than 0.4 and an unlighted contrast C_{UL} with an absolute value less than or equal to 0.1 under 10 000 fc of illumination as defined in MIL-L-85762A and MIL-PRF-22885G when set at full rated voltages.

4.1.1.1 Test Arrangement: The test arrangement must be as shown in Figure 6 where the 10 000 fc source is set to an angle of 15° off the normal to the display and is the angle of incidence. The photometer is set at the angle of reflectance of 15°.

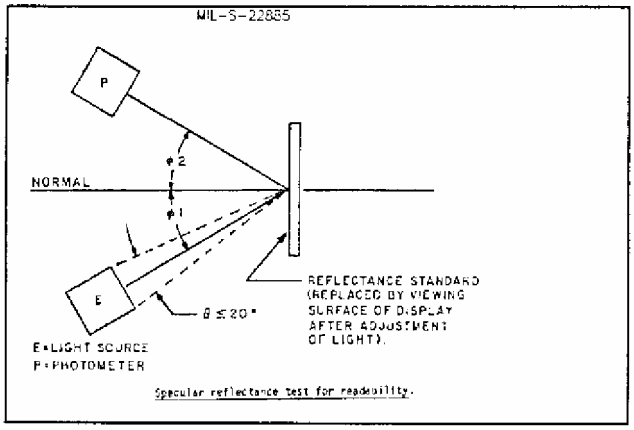

FIGURE 6

4.1.1.2 Contrast Requirements: The contrast requirements for C_L and C_{UL} are:

$$\text{The On/Background contrast } C_L = \frac{B_2 - B_1}{B_1} \geq 0.4$$

$$\text{The Off/Background contrast } C_{UL} = \frac{B_3 - B_1}{B_1} \leq 0.0 \pm 0.1 \qquad \text{(Eq. 2)}$$

where:

B_1 = Average background luminance

B_2 = Average character luminance, lighted

B_3 = Average character luminance, unlighted

The average character and background luminance measurements should include three readings per character in accordance with the sunlight readability test procedure defined in MIL-S-22885.

4.1.2 Daylight Readability Excluding Specular Sunlight: Illuminated pushbutton switches and indicators not requiring readability in direct reflected specular sunlight must have a contrast, C_L, of not less than 1.0 in a 10 000 fc diffuse white light environment as defined in MIL-S-38039.

4.1.2.1 Test Arrangement: The test arrangement is not defined in MIL-S-38039 but a suggested test arrangement is shown in Figure 7.

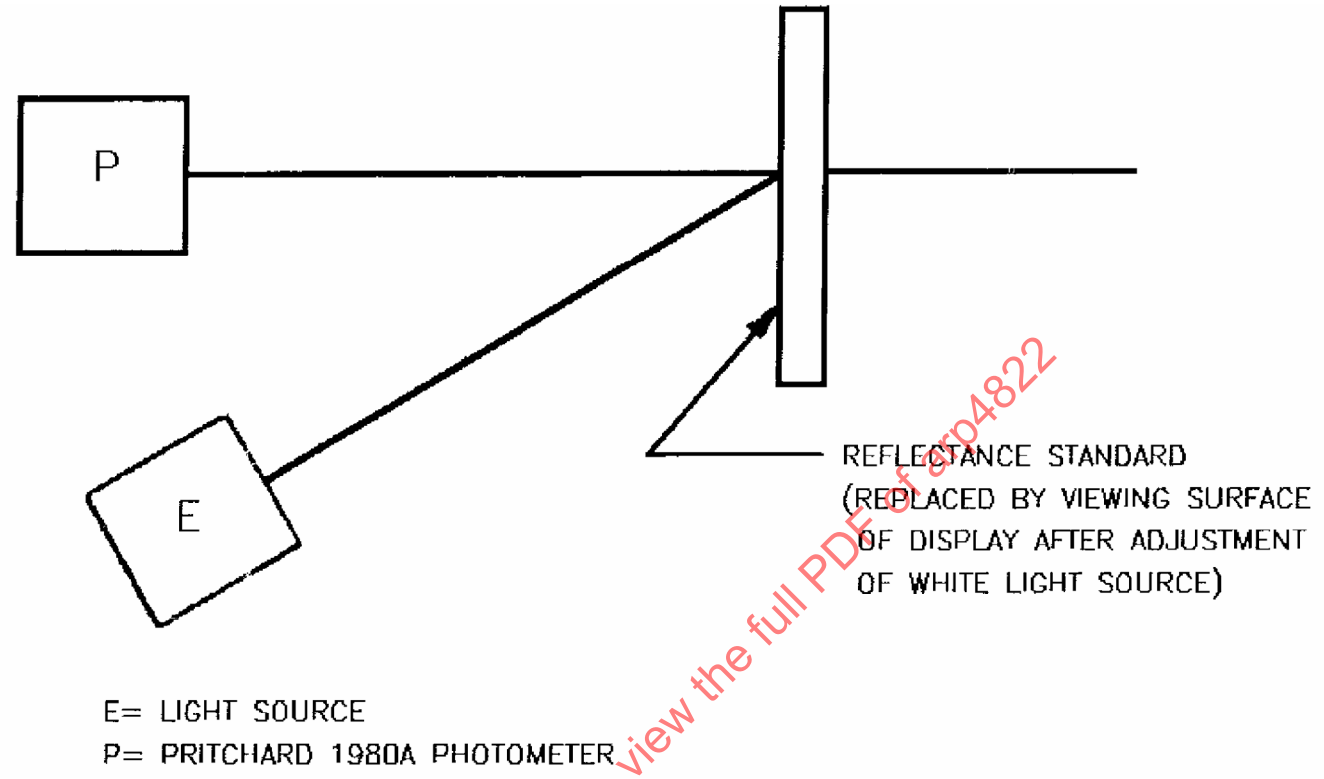

FIGURE 7

4.1.2.2 Contrast Requirement: The contrast requirements for C_L is:

$$\text{Contrast } C_L = \frac{B_2 - B_1}{B_1} \geq 1.0 \qquad \text{(Eq. 3)}$$

where:

B_1 = Average brightness of the unlighted portion

B_2 = Average brightness of the lighted portion

The average character and background luminance measurements should include three readings per character in accordance with the sunlight readability test procedure defined in MIL-S-22885.

4.1.3 Special Considerations:

4.1.3.1 Specular Reflections: The sunlight readability test requiring readability in direct reflected specular sunlight is the most severe test for sunlight readability. It represents the worst case situation where the display is exposed to direct sunshine and positioned such that the pilot sees a specular reflection of the sun. In this case it is recommended that the display have hidden legends and a low reflective, diffuse front surface to avoid ghosting (appearing illuminated when unenergized) and to eliminate surface specular reflections.

4.1.3.2 Contrast Values: The specular sunlight contrast value of $C_L \geq 0.4$ has been reduced from 0.6 minimum to allow for the additional filtering necessary to achieve NVIS compatibility. A contrast of 0.4 is marginally acceptable and it is desirable for displays to have higher contrast values for improved sunlight readability.

4.1.3.3 Minimum Display Luminance: It is recommended that a display have a minimum average luminance of 250 fL at full rated voltage to meet the requirements for sunlight readability. Displays with an average luminance less than 250 fL may be difficult to recognize in high illuminance conditions.

4.2 Caution and Advisory Displays Using NVIS Green A or Green B:

Illuminated pushbutton switches and indicators that are used as caution and advisory signals in an NVIS compatible crew station must meet the requirements of MIL-L-85762A.

4.2.1 Chromaticity and Luminance Requirements:

4.2.1.1 NVIS Green A: The color of caution and advisory displays are required to be NVIS Green A when they are set to produce 0.1 fL. The NVIS Green A color is the area within a circle whose radius is 0.037 and is located at $u_o = 0.088$ and $v_o = 0.543$ on the CIE 1976 UCS Diagram (see Figure 8). This is the same color requirement as that required for primary instrument and panel lighting.

4.2.1.2 NVIS Green B: MIL-L-85762A recognizes that in some cases NVIS Green A displays may not produce sufficient brightness to be sunlight readable. As an alternative the specification allows displays to be NVIS Green B where increased display emphasis by highly saturated colors is necessary or adequate display sunlight readability cannot be achieved with NVIS Green A. The NVIS Green B color is the area bounded by the spectral locus and a circle whose radius is 0.057 and is located at $u_o = 0.131$ and $v_o = 0.623$ shown in Figure 8. The display must produce this color when set to 0.1 fL.

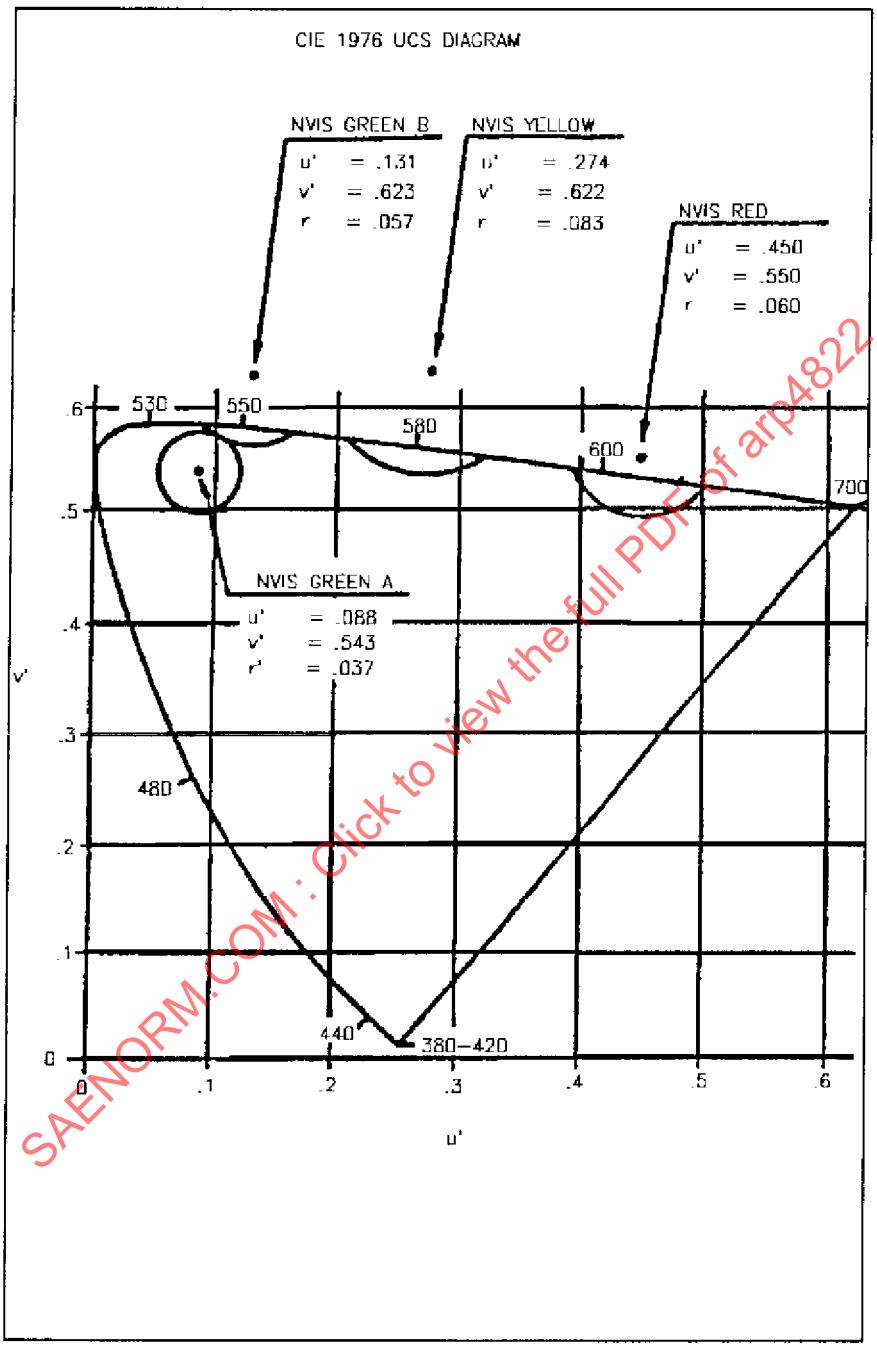

FIGURE 8

4.2.1.3 NVIS Radiance Requirements: The NVIS radiance of caution and advisory displays must be less than 1.7×10^{-10} when set to produce 0.1 fL. The NVIS radiance is calculated using the Class A response curve. This is the same radiance requirement as that required for primary instrument and panel lighting. The NVIS radiance is measured at 15 fL then scaled down to 0.1 fL since MIL-L-85762A requires the measurement to be made at full rated voltage or 15 fL, whichever is less.

4.2.2 Special Considerations:

4.2.2.1 Visual Appearance of NVIS Green A: The NVIS Green A region includes various shades of blue-green, green, and yellowish-green. In some applications this nonuniformity of color can be a problem. In these instances the color requirement is tightened to allow only colors in the upper half of the NVIS Green A region.

4.2.2.2 Dimming Effect on NVIS Green A: When incandescent lamps are used in sunlight readable, caution, and advisory displays, a significant shift in lamp color temperature occurs when dimming from full rated voltage to 0.1 fL where the color is actually measured. This can cause a significant shift in the display's color from a bluish-green (near the center of NVIS Green A) at full voltage to a yellowish-green (near the upper right limit) at 0.1 fL. The display should be designed so that it meets the NVIS Green A color requirements at full voltage and at 0.1 fL.

4.2.2.3 Visual Appearance of NVIS Green B: The NVIS Green B color is green to yellowish-green in appearance with reasonably good color uniformity within the specification limits.

4.2.2.4 Dimming Effects on NVIS Green B: The NVIS Green B color exhibits a slight shift in color when dimmed from full voltage down to 0.1 fL (because of the shift in lamp color temperature). The shift is not as great as for the NVIS Green A color. The display should be designed so that it meets the NVIS Green B requirement both at full voltage and at 0.1 fL.

4.2.2.5 Class B NVIS Radiance: Caution and advisory displays specified for use in Class B NVIS crew stations must meet the MIL-L-85762A NVIS radiance requirements using the Class A NVIS relative spectral response. This is done to insure interchangeability of displays between Class A and Class B NVIS compatible cockpits. This also applies to primary instrument and panel lighting.

4.2.2.6 Usage of NVIS Green A and Green B Displays: NVIS Green A and Green B displays, conforming to the NVIS radiance requirements, may be used in any quantity or in any position within an NVIS compatible cockpit without causing too much interference.