



AEROSPACE RECOMMENDED PRACTICE

ARP4169™**REV. B**

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Superseding ARP4169A

Night Vision Goggle (NVG) Filters

RATIONALE

To update the document to reflect advances in NVIS technology and to update any references as required.

ARP4169B has been reaffirmed to comply with the SAE Five-Year Review policy.

1. SCOPE

This SAE Aerospace Recommended Practice (ARP) discusses the desired characteristics of night vision goggle (NVG) filters that can be used with incandescent, electroluminescent (EL) and light emitting diode (LED) light sources to achieve NVG compatible lighting of aerospace crew stations. This document also discusses the parameters that need to be considered when selecting a night vision goggle/daylight viewing (NVG/DV) filter for proper contrast enhancement to achieve readability in daylight.

The recommendations set forth in this document are to aid in the design of NVG compatible lighting that will meet the requirements of MIL-L-85762A and MIL-STD-3009.

1.1 Purpose

This document describes the functions and characteristics of NVG filters used in NVG compatible lighting.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

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ARP4168 Night Vision Goggle (NVG) Compatible Light Sources

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2.1.2 U.S. Government Publications

Available from DLA Document Services, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-6396, <http://quicksearch.dla.mil/>.

MIL-L-85762A Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible

MIL-STD-3009 Lighting, Aircraft, Night Vision Imaging System (NVIS) Compatible

2.2 Definitions

2.2.1 NIGHT VISION GOGGLE COMPATIBLE LIGHTING

The condition in which the spectral wavelengths, luminance level and uniformity of the cockpit lighting do not interfere with the operation of night vision goggles thus permitting the night vision goggle user to observe an image intensified outside without degradation while maintaining the ability to recognize master caution/warning indicators and to easily interpret all lighted information in the crew station with unaided eyes.

3. FUNCTIONS OF AN NVG FILTER

3.1 The three primary functions of an NVG filter are:

3.1.1 Suppress the deep red and infrared wavelengths emitted by a light source required for NVG compatibility as defined by the Class of NVIS minus blue filter (see Section 5 of this document and Section 1.3 of MIL-L-85762A or MIL-STD-3009).

3.1.2 Limit visible transmission values for wavelengths amplified by the particular NVIS class.

3.1.3 Provide a color shift to the desired NVG color range.

3.2 Contrast Enhancement

An NVG/DV filter is used to provide sufficient contrast enhancement to achieve viewability in daylight or sunlight ambients. For this document, a daylight ambient is considered to be less than 10 000 foot-candle and above 6000 foot-candle, as may be defined by the end use application, and sunlight ambient is considered to be 10 000 foot-candle.

4. TYPES OF NVG FILTERS

4.1 Two Basic Types of NVG Filters

This document defines and discusses two basic types of NVG filters: the night vision goggle (NVG) and the night vision goggle/daylight viewing (NVG/DV).

4.1.1 Night Vision Goggle (NVG) Filter

The night vision goggle (NVG) filter defined in this document is a short wavelength pass filter, designed primarily to provide red and infrared (IR) suppression to achieve NVG compatibility. Contrast enhancement for readability in bright ambient is not provided by the NVG filter.

4.1.2 Night Vision Goggle/Daylight Viewing (NVG/DV) Filter

The night vision goggle/daylight viewing (NVG/DV) filter defined in this document is a bandpass filter, designed to provide both red and IR suppression for NVG compatibility and contrast enhancement for viewability in daylight or sunlight ambient.

4.2 NVG Filter Materials

The basic materials used to make NVG filters are glass, glass composite and plastic.

4.2.1 Glass NVG and Glass Composite NVG/DV Filters

Glass NVG and glass composite NVG/DV filters may be obtained with or without a front surface antireflection (AR) coating to enhance viewability. Glass and glass composite filters provide superb IR suppression for incandescent light sources and are excellent with EL and LED light sources. Glass composite filters for use in NVG applications typically do not contain circular polarizers.

4.2.2 Plastic NVG Filters

Plastic NVG filters are typically made from either polycarbonate or acrylic and provide good IR suppression for EL and LED light sources. Plastic filters may provide only marginal IR suppression for incandescent light sources. Typically, plastic NVG filters do not provide sufficient contrast enhancement for sunlight viewing.

4.3 Environmental Requirements and NVG Filter Materials

The NVG filter material selected must be capable of withstanding the military environmental requirements specified for the particular piece of equipment in which the filter is to be used. The equipment environmental specification may include requirements for such items as temperature, mechanical shock, moisture resistance, salt spray, chemical resistance and UV stability.

Glass glass composite and some plastic filters can withstand temperatures from -55 to +100 °C. Some plastic NVG filter materials, such as polycarbonate, are not recommended for use in high humidity environments above 85% RH, noncondensing. Plastic filters can be obtained with a scratch resistant front surface.

5. GEN III NVIS MINUS BLUE FILTERS

GEN III night vision imaging systems use filters, termed minus blue filters, in conjunction with the objective lenses to reduce the NVIS sensitivity to visible light. These minus blue filters are long pass filters, attenuating the visible spectrum below the red region and passing infrared.

5.1 Minus Blue Filters for NVIS Class A and NVIS Class B

GEN III NVIS are classified by Figures 1 and 2 of MIL-L-85762A as to wavelength where the value of the relative transmission of their minus blue filters is 50%. Figure 1 shows the relative GEN III responses: $G_A(\lambda)$ for NVIS Class A and $G_B(\lambda)$ for NVIS Class B. The GEN III response curves of Figure 1 are plotted with data from Tables VI and VII of MIL-L-85762A.

5.2 Minus Blue Filters for NVIS Class C

For those aircraft that use a Heads-Up Display (HUD) and operate with direct view NVG's (Type I), a NVIS Class C filter will be necessary. With NVIS Class A or B filters, pilots will not be able to detect the symbology on the HUD combiner glass since the radiometric energy is very saturated in a very narrow wavelength typically around 545 nm which both Class A and Class B filters block. The Class C filter incorporates a minimum and maximum transmission around the 545 nm wavelength to allow the direct view NVG's to detect the HUD symbology. The Class C filter is sometimes called the "leaky green" filter. Figure 3 details the transmission allowances for a Class C filter. Be aware that a small number of HUD phosphors are not visible through the leaky green Class C NVIS but may be visible with Class A or B NVIS. The NVG specifier is advised to confirm the HUD phosphor type in use in the aircraft in which the use of NVG is contemplated. Not all HUD phosphor will peak within the narrow band width of where the "leak" is located, so take this into consideration if NVG's will be employed for the aircraft.

6. NVIS RADIANCE AS DEFINED BY MIL-L-85762A

6.1 Definition of NVIS Radiance

MIL-L-85762A defines acceptable spectral radiance levels, as detected by a GEN III night vision imaging system, for various lighting configurations. This spectral radiance is termed NVIS Radiance, NR, and is determined from Equation 1:

$$\text{NVIS Radiance (NR)} = G(\lambda)_{\text{MAX}} \int_{450}^{930} G(\lambda) S N(\lambda) d(\lambda) \quad (\text{Eq. 1})$$

where:

$G(\lambda)$ = Relative NVIS response, Class A, Class B, or Class C

S = Measurement scaling factor, which is the ratio of required luminance for NVIS Radiance to the luminance needed by the spectroradiometer to make the measurement, or 15 foot-lambert, whichever is less

$G(\lambda)_{\text{MAX}}$ = 1 mA/W

$d\lambda$ = 5 nm

$N(\lambda)$ = $f(\lambda)T(\lambda)$ W/cm²/sr/nm

$f(\lambda)$ = Radiated spectrum of light source

$T(\lambda)$ = Relative transmission of NVG filter

6.2 The relative transmission characteristic, $T(\lambda)$, for the NVG filter in the IR region has the most influence on the value of NVIS Radiance. The amount of IR suppression and the relationship of the NVG filter $T(\lambda)$ long wavelength characteristic with respect to the $G_A(\lambda)$ or $G_B(\lambda)$ short wavelength characteristic strongly influences the NR value for a given light source.

7. SUGGESTED NVG FILTER CHARACTERISTICS

7.1 Suggested NVG Filter IR Suppression Characteristics

This document suggests criteria for two primary parameters of NVG filter characteristics, described in relationship to NVIS relative response characteristics, for obtaining sufficient IR suppression to meet the requirements of MIL-L-85762A or MIL-STD-3009. These two NVG filter characteristics are (1) the intersection of the NVG filter long wavelength characteristic with the NVIS relative response short wavelength characteristic and (2) the slope of the NVG filter long wavelength characteristic. The filter transmission characteristics should be graphed as a semi-log plot, as shown in Figure 2, since a linear plot does not show the necessary IR attenuation.

7.1.1 The suggested IR suppression characteristics of an NVG filter are illustrated in Figure 2. The IR suppression should be continuous out to 930 nm. For incandescent light sources, the IR suppression should be not less than six orders of magnitude beyond 650 nm. For EL and LED light sources, the IR suppression should be not less than four orders of magnitude beyond 650 nm.

The peak wavelength of the NVG filter characteristic shown in Figure 2 is located with the color range for NVIS A. The peak wavelengths of the NVG/DV filters characteristics shown in Figures 4, 5, and 6 are located within the respective NVIS color ranges, NVIS GREEN B, NVIS YELLOW, and NVIS RED.