INCH-POUND
MIL-L-85762A
26 August 1988
SUPERSEDES
MIL-L-85762
24 January 1986

MILITARY SPECIFICATION

LIGHTING, AIRCRAFT, INTERIOR, NIGHT VISION IMAGING SYSTEM (NVIS) COMPATIBLE

This specification is approved for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification establishes performance, general configuration, test and acceptance requirements for NVIS (see 6.5.1) compatible aircraft interior lighting. It is applicable to all systems, subsystems, component equipment and hardware which provide the lighting environment in aircraft crewstations and compartments where NVIS are employed.

1.2 Purpose. The purpose of this specification is to provide performance requirements and testing methodology to ensure effective and standardized aircraft interior lighting for NVIS compatibility.

1.3 Classification. Night Vision Imaging System (NVIS) compatible aircraft interior lighting shall be of the following types and classes, as specified (see 6.2.b).

Type I	Lighting compatible with any Direct View Image NVIS (see 6.5.1.1) utilizing generation III Image intensifier tubes.
Type II	Lighting compatible with any Projected Image NVIS (see 6.5.1.2) utilizing generation III Image intensifier tubes.
Class A	Lighting compatible with NVIS utilizing 625 nm minus blue objective lens filters (see 6.5.1.3) with the specifications of Figure 1.
Class B	Lighting compatible with NVIS utilizing 665 nm minus blue objective lens filters (see 6.5.1.4) with the specifications of Figure 2.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Systems Engineering and Standardization Department (Code 93), Naval Air Engineering Center Lakehurst, NJ 08733, by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

AMSC NO. N4524 FSC 6220

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2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbooks. The following specifications, standards, and handbooks form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation (see 6.2.c).

SPECIFICATIONS

MIL-R-22 - Resistors, Variable (Wire-wound, Power Type), General Specification for

MIL-L-5057 - Light, Instrument, Individual, General Specification for

MIL-B-5087 - Bonding, Electrical, Lightning Protection for Aerospace Systems

MIL-W-5088 - Wiring, Aerospace Vehicle

MIL-E-6051 - Electromagnetic Compatibility Requirements, Systems

MIL-L-6503 - Lighting Equipment, Aircraft, General Specification For Installation of

MIL-C-6781 - Control Panel Aircraft Equipment, Rack or Console Mounted

MIL-E-7080 - Electric Equipment, Aircraft, Selection and Installation of

MIL-P-7788 - Panels, Information, Integrally Illuminated

MIL-M-8650 - Mockups, Aircraft, Construction of

MIL-H-8810 - Handles, Control, Aircraft

MIL-M-18012 - Markings for Aircrew Station Displays Design and Configuration of

MIL-L-18276 - Lighting, Aircraft Interior, Installation of

MIL-I-18373 - Instruments and Navigation Equipment, Aircraft Installation of

MIL-S-22710 - Switches, Code Indicating Wheel (Printed Circuit), (Thumbwheel and Pushbutton), General Specification for

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MIL-S-22885 - Switch, Push Button, Illuminated, General Specification for

MIL-K-25049 - Knobs, Control, Electronic Equipment, Aircraft

MIL-L-25467 - Lighting, Integral, Red Aircraft Instrument, General Specification for

MIL-L-25866 - Light, Emergency Exit, Aircraft LEU 1-A

MIL-L-27160 - Lighting, Instrument, Integral, White General Specification For

MIL-T-27493 - Transformer, Variable, Single Phase, 400 Cycles, General Specification for

MIL-S-38039 - Systems, Illuminated, Warning, Caution, and Advisory, General Specification for

MIL-D-87157 - Display, Diode, Light Emitting, Solid State, General Specification for

STANDARDS

MIL-STD-130 - Identification Marking of U.S. Military Property

MIL-STD-143 - Standards and Specifications, Order of Precedence for the Selection of

MIL-STD-150 - Photographic Lenses

MIL-STD-203 - Aircrew Station Controls and Displays; Assignment, Location, and Actuation of, for Fixed Wing Aircraft

MIL-STD-250 - Aircrew Station Controls and Displays for Rotary Wing Aircraft

MIL-STD-411 - Aircrew Station Signals

MIL-STD-461 - Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement of

MIL-STD-704 - Aircraft Electrical Power Characteristics

MIL-STD-882 - System Safety Program Requirements

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MIL-STD-1333 - Aircrew Station Geometry for Military Aircraft

MIL-STD-1472 - Human Engineering Design Criteria for Military Systems, Equipment and Facilities

MIL-STD-1776 - Aircrew Station and Passenger Accomodations

HANDBOOKS

USAF, AFSC Design Handbook, DH 1-3

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Naval Publications and Forms Center, (ATTN: NPODS), 5801 Tabor Avenue, Philadelphia, PA 19120-5099.)

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein, the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS

3.1 Description. This specification defines the performance requirements and test procedures applicable to NVIS compatible lighting systems for new or modified aircraft lighting equipment and crewstations when specified in the weapon system design specification.

3.2 Selection of specifications and standards. Specifications and standards for necessary commodities and services not specified herein or in the individual equipment specifications shall be selected in accordance with MIL-STD-143.

3.3 First article. When specified in the contract or purchase order (see 6.2.d), a sample shall be subjected to first article inspection (see 4.4 and 6.4).

3.4 Mockup. When required by the acquiring activity (see 6.2.g) prior to incorporation into production or redesigned aircraft, an aircrew station mockup shall be prepared and made available by the contractor to ensure compliance with the NVIS compatibility and lighting system, subsystem or component requirements specified herein. When inspected in accordance with 4.8.1, 4.8.2, and 4.8.3 the aircrew station mockup shall conform to all of the requirements of this specification as applicable. There shall be no evidence of degraded NVIS resolution in the presence of aircraft interior lighting when the observer is looking outside of, or transitioning from inside to outside of the aircraft.

3.4.1 US Navy and US Army. For U.S. Navy and U.S. Army acquisitions the mockup shall conform to MIL-M-8650.

3.4.2 US Air Force. For U. S. Air Force acquisitions, the mockup shall conform to the mockup design requirements in MIL-L-6503 and the mockup requirements in the U.S. Air Force AFSC Design Handbook, DH 1-3.

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3.5 Equipment. Unless otherwise specified herein, lighting equipment for U.S. Navy and U.S. Army aircraft shall be in accordance with MIL-L-18276. For U.S. Air Force aircraft, lighting equipment shall be in accordance with MIL-L-6503. When used, light emitting diode displays shall be in accordance with MIL-D-87157.

3.6 Wiring. Wiring shall be in accordance with MIL-W-5088.

3.7 Bonding. Bonding shall be in accordance with MIL-B-5087.

3.8 Installation. Aircraft lighting equipment installation shall be in accordance with MIL-E-7080. When lights are installed in areas subject to a differential in air pressure, a pressure barrier shall be provided between the pressurized section and the lights. Lighting fixtures shall not be used as part of the pressure barrier. All lights shall be oriented and all components shall be so indexed or designed that the lights are properly aimed when replaced or reassembled after relamping.

3.8.1 Accessibility. Accessibility of connectors shall be in accordance with MIL-STD-1472.

3.9 Design. Wherever possible, standard fixtures shall be used. Nonstandard fixtures approved by the acquiring activity may be used whenever aircraft configuration is such that performance requirements cannot be met by the use of standard fixtures as described in the applicable documents cited herein. The number of different types of lighting equipment, light sources, and power shall be kept to a minimum in any given aircraft installation. All lighting sources shall track together in luminance over the entire range of the lighting system in accordance with 3.9.5.2.

3.9.1 Lighting provisions. The design and location of the lighting equipment shall optimize visual performance and minimize the effects on NVIS. When necessary, the lights shall be shielded to prevent direct or indirect glare from interfering with the aircrewmember's interior or exterior unaided vision and with the image intensification capabilities of the NVIS. Lighting equipment shall be so designed that: (1) prescribed ground and in-flight maintenance of the lamp can be accomplished without damaging or degrading the performance of the equipment; and (2) the lamps will give satisfactory service under the environmental conditions specified by the acquiring activity.

3.9.2 Light sources. Light sources shall meet all of the requirements herein, and shall be compatible with space, weight, and power constraints of the aircraft. Other issues which shall be considered in the selection of light sources are:

a. design, production, support cost (i.e. life cycle costs)

b. reliability

c. operating efficiency

d. heat generation

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3.9.3 Power source. The console and instrument secondary lighting subsystems and the emergency lighting subsystem, when provided, shall be connected to the essential bus of the aircraft electric system. The other lighting subsystems shall be connected to the primary bus.

3.9.3.1 Protective devices. Circuit breakers, fuses, or other protective devices shall be provided to automatically disconnect the power from the light circuits in the event of a ground or short in the lighting fixtures, circuits, or controls.

3.9.4 Lighting power. Lighting subsystems shall be designed to operate from the applicable power circuits as specified in MIL-STD-704. Unless otherwise specified by the acquiring activity, the lighting subsystem shall be designed to operate from a 5 V ac (400 Hz), 5 V dc, 28 V dc, or a 115 V ac (400 Hz) power source.

3.9.5. Lighting control location and actuation. Lighting controls shall be provided to allow each crewmember to control the intensity of all of the interior lighting subsystems that provide illumination for his crewstation. Lighting units related by function or area shall have common controls as required by the aircraft mission (e.g., functionally related units such as flight instruments or navigation controls). An adequate number of controls shall be provided to allow the crewmember the flexibility to reduce glare, distractions, and fatigue.

3.9.5.1 Lighting control panels. Standard control panels in accordance with MIL-C-6781 shall be provided for control of interior aircraft lighting. Inspection shall be in accordance with 4.8.3.

3.9.5.1.1 Control panel location. Each crewstation shall be provided with a lighting control panel, convenient for operation by that aircrewman for controlling all lights that are usually employed by that aircrew member only. For lights which are usually employed by two aircrew members, lighting control panel(s) convenient for operation by both of those aircrew members should be provided. Controls shall conform to the requirements of MIL-STD-203 or MIL-STD-250 unless otherwise approved by the acquiring activity or specified herein. Control panels shall be located to permit unaided eye viewing by an aviator wearing NVIS without requiring extreme head movements.

3.9.5.2 Controls. The instrument and console lighting controls shall be equipped with rotary control knobs in accordance with MIL-K-25049. These controls shall allow the intensity of the lighting to be varied from "OFF" in the extreme counterclockwise position, over the full range of the control to maximum "BRIGHT" at the extreme clockwise position. The lighting intensity shall be varied in log footlamberts with control movement from minimum to maximum "BRIGHTNESS". An "OFF" position shall be provided at the minimum control end of travel. Lighting luminance uniformity shall be in accordance with 3.10.11. Variable autotransformers or rheostats may be used depending upon the type of power utilized. When rheostats are used, they shall be in accordance with MIL-R-22. Autotransformers shall be in accordance with MIL-T-27493. Other controls determined to be more suitable for the NVIS application may be used subject to acquiring activity approval. For each individual electro-optical display, a separate intensity control shall be provided.

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3.9.6 Auxiliary covers. If auxiliary covers are installed over the lighting fixtures, the covers shall not cause the light output to fall outside of the light intensity limits of the individual equipment specification. The covers shall not cause light to be reflected or directed to interfere with the aviator's unaided eye vision or the image intensification capabilities of the NVIS. The covers shall not fail or become distorted when the lamps are operated in a continuously energized mode during the designated mission. The covers shall meet the environmental requirements for the lighting fixture. The covers shall be provided with captive quick-disconnect type fasteners to insure easy and rapid removal for prescribed lamp maintenance actions.

3.9.7 Markings. Markings for information panels, control panels, instruments, controls, and placards shall be selected, arranged and marked in accordance with MIL-M-18012.

3.9.7.1 Identification. Marking for identification shall be in accordance with MIL-STD-130. In addition, each component shall be marked with "NVIS Type ( ), Class ( )."

3.9.8 Instrument range markings. Instrument range markers shall conform to the requirements of MIL-I-18373.

3.9.9 Critical information and control presentation. The day and night presentation of controls and control and display areas designated as immediate action shall conform to the requirements of MIL-M-18012. To maintain NVIS compatibility, the NVIS radiance (see 6.5.8) requirements of 3.10.9 shall apply.

3.9.10 Instrument and display lighting. Instruments and displays shall be provided with primary and secondary lighting subsystems as specified herein.

3.9.10.1 Primary instrument and display lighting. The primary instrument and display lighting subsystem shall consist of integrally illuminated information panels conforming to the requirements of MIL-P-7788 and integrally lighted instruments and displays in accordance with MIL-L-25467 for U.S. Navy and U.S. Army aircraft and MIL-L-27160 for U.S. Air Force aircraft. Moveable portions of integrally illuminated instrument displays when placed in any position within their designated range shall not cause the NVIS radiance readings to exceed the specified limits. Individual lighting fixtures for each instrument conforming to MIL-L-5057 may be used if specifically approved by the acquiring activity. The chromaticity and spectral radiance limits of the illuminated portions of the panels and instruments shall be in accordance with 3.10.8 and 3.10.9 respectively. Lights specified in MIL-L-5057 for each instrument shall be installed in the number, location(s), and orientation(s) for the instrument case for which the light is qualified. For lighting fixtures having lead wires without sockets, sufficient length shall be provided in the electrical lead of each instrument light in order that 3.5 to 4.0 inches of the lead can be readily pulled through the instrument panel upon removal of the light from the instrument or panel. The surface color of information plates shall be black in accordance with MIL-P-7788, in areas where NVIS are employed.

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3.9.10.2 Secondary instrument and display lighting. The secondary instrument and display lighting, when required by the acquiring activity (see 6.2.h), shall provide instrument and display illumination levels as required in Table I. The chromaticity and spectral radiance limits shall be as specified in 3.10.8 and 3.10.9 respectively. Sufficient lights shall be employed to provide adequate illumination subject to the mockup approval. When these lights are installed on the underside of the glare shield of the instrument panel, they shall be located as far aft on the glare shield as practicable and designed to minimize glare and stray light outside of the area of intended illumination.

3.9.11 Electronic and electro-optical displays. Electronic and electro-optical displays shall meet the NVIS radiance requirements stated in 3.10.9.9 except those used in head up display (HUD) systems. HUD system NVIS radiance limits shall be as specified in 3.10.9.10.

3.9.12 Console lighting. All consoles (center, side, or overhead) shall be provided with primary and secondary lighting, as specified herein.

3.9.12.1 Primary console lights. The console primary lighting subsystem shall consist of integrally lighted information panels and instrument lighting in accordance with the requirements of 3.9.10. The lighting color shall be as specified in 3.10.8 with the spectral radiance limits as specified in 3.10.9.

3.9.12.2 Secondary console lights. When required by the acquiring activity (see 6.2.i), the console secondary lighting subsystem, shall provide visibility of the panel surface, displays, and panel mounted controls (switches, levers, handles, knobs, guards, etc). The lighting fixtures for this purpose shall provide console illumination levels as specified in Table I. Chromaticity and spectral radiance limits shall be as specified in 3.10.8 and 3.10.9 .

3.9.13 Compartment lighting. All flight and nonflight compartments shall be provided with suitable lighting for the aircrew and passengers. Dual mode (white/NVIS compatible) compartment lighting may be used. The design shall preclude inadvertent actuation of the non-NVIS compatible lighting mode. This lighting shall allow the crew and passengers normal ingress and emergency egress within the aircraft interior. The lights shall be so located and, if necessary, shielded to prevent them from being a source of direct or reflected glare to aircrewmembers or being seen by outside observers. Lighting, as required by the acquiring activity (see 6.2.j) shall be provided for the cargo compartment, loading and ramp areas, passageways, passenger seating area and auxiliary power plant compartment. The lighting fixtures should be mounted as dome, ceiling, cornice, or aisle lights. Chromaticity and spectral radiance limits shall be as specified in 3.10.8 and 3.10.9. Illuminance levels shall be as required in Table I, unless otherwise specified by the acquiring activity.

3.9.14 Utility lighting. One or more utility lights for use in illuminating maps, charts, or general work areas shall be provided for each crewstation. Chromaticity and spectral radiance limits shall be as specified in 3.10.8 and 3.10.9. The light shall be equipped with a self-contained intensity control

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whereby the light output can be uniformly varied from off to full-bright over the control range. The utility lighting subsystem may be used as an emergency lighting subsystem in the event of failure of the primary or secondary instrument and console lighting subsystems.

3.9.15 High intensity lighting subsystem. When required by the acquiring activity (see 6.2.k), flight compartments shall be provided with a floodlighting system for illuminating the instrument panels and consoles with unfiltered white light. The illumination shall be a minimum of 150 footcandles (fc) for the flight instruments and a minimum of 75 fc for other instruments and controls in the flight compartment. A continuously variable manual intensity control shall be provided. In addition, in aircraft equipped with an automatic thermal protective closure system, the light(s) shall be automatically turned on to full bright when the closure is activated. A momentary contact reset switch shall be provided to regain manual control.

3.9.16 Emergency exit lighting. When required by the acquiring activity (see 6.2.l), emergency exit lighting fixtures shall be provided in sufficient number and with adequate visibility to permit the aircrew and untrained personnel to orient themselves, read exit operating instructions, actuate the exit mechanism without difficulty, and egress from the aircraft under adverse environmental conditions (e.g. smoke, turbid waters, etc.). Lighting fixtures may serve more than one specific purpose (e.g. exit location signs also serving as the exit path light). Emergency exit lights conforming to the requirements of MIL-L-25866 generally meet these performance criteria. Emergency exit lighting subsystems that may be automatically activated during flight shall meet the spectral radiance requirements in 3.10.9.7.

3.9.16.1 Automatic and manual actuation. All emergency lighting components shall be designed to be actuated both automatically and manually. A switch which can be used for activating and resetting all of the emergency lighting units shall be located in the flight compartment. The emergency exit lighting subsystem shall have self-contained power that may be actuated from one or more common sensing devices. These sensing devices shall be approved by the acquiring activity. The circuits for the lights shall be such that they will be energized in the event that the circuits between the lights and the sensors are broken.

3.9.17 Crewstation controls and control handles. Crewstation control knobs shall be in accordance with MIL-K-25049, lighted push button switches shall be in accordance with MIL-S-22885, lighted thumbwheel or indicating wheel pushbutton switches shall be in accordance with MIL-S-22710, and control handles shall be in accordance with MIL-H-8810. The lighted color and spectral radiance limits for illuminated controls shall be as specified in 3.10.8.3 and 3.10.9.3. To maximize contrast with the control panel, knobs shall be white with black indices.

3.9.18 Warning, caution, and advisory signals. Unless otherwise specified herein, specific requirements for dedicated warning, caution, and advisory signals shall be in accordance with MIL-STD-411.

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3.9.18.1 Caution and advisory signals. Caution and advisory signals shall be presented, arranged and located as specified in MIL-STD-411 in addition to the following:

(a) The location shall permit unaided eye viewing by an aviator wearing NVIS without extreme head movement.

(b) The brightness and reset requirements of the caution and advisory signals shall be as specified in MIL-STD-411 except that these signals shall have dimming capability down to 0.1 footlamberts (fL).

(c) Chromaticity limits shall be as specified in 3.10.8.6 and the NVIS radiance requirements shall be as specified in 3.10.9.6.

3.9.18.2 Verbal and non-verbal auditory signals. To increase the probability of the aircrewmember(s)' response to either warning or caution events, appropriate verbal or non-verbal auditory signals augmenting the light signals may be employed. These signals shall be subject to the approval of the acquiring activity.

3.9.19 Jump lights. The NVIS radiance of jump lights shall be as specified in 3.10.9.7 and chromaticity limits shall be as specified in 3.10.8.7. Different geometric shapes and sizes shall be used to distinguish the "caution light" from the "jump light" when viewed through the NVIS. The specific geometric shape designs shall be approved by the acquiring activity.

3.9.20 Other light indications and signals. Other specific lighted displays (e.g. equipment status, navigational, ordnance, etc.) shall meet the chromaticity limits specified in 3.10.8.1 and NVIS radiance requirements of 3.10.9.1 when inspected in accordance with 4.8.13 and 4.8.14.

3.9.21 Checklist and radio call plates. When required by the acquiring activity (see 6.2.m), each check list and radio call plate shall be an integrally lighted information plate in accordance with MIL-P-7788 except that the chromaticity and NVIS radiance limits shall be as specified in 3.10.8.1 and 3.10.9.1. The lighting of these plates shall be controlled by the primary instrument lighting system control.

3.9.22 Work and inspection lights. When provided as part of the aircraft, work and inspection lights shall meet the chromaticity and NVIS radiance limits specified in 3.10.8.5 and 3.10.9.5.

3.10 Performance.

3.10.1 Daylight and night operation. Crewstations shall be provided with lighting and lighting controls appropriate for day and night flight operations.

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3.10.2 Daylight legibility and readability.

3.10.2.1 Illuminated visual signals.

a. Illuminated visual signals (indicators, readouts, controls, and pushbutton switches) requiring readability in direct reflected specular sunlight shall have contrast requirements C_L not less than 0.4 and C_{UL} equal to 0.0 $\pm$ 0.1 as defined in MIL-S-22885 and 4.8.16.2 under a 10,000 footcandle illumination level at rated drive conditions. Inspection shall be in accordance with 4.8.16.1.

b. Illuminated visual signals not requiring readability in direct reflected specular sunlight shall have contrast of not less than 1.0 as defined in MIL-S-38039 at rated drive conditions. Inspection shall be in accordance with 4.8.16.1.

3.10.2.2 Monochrome electronic and electro-optical displays. Monochrome electronic and electro-optical displays to be used in direct sunlight shall be readable in a combined environment consisting of 10,000 fc diffuse illuminance and the specular reflection of a 2000 fL glare source at rated drive conditions. These displays shall meet the minimum contrast and difference luminance requirements specified herein. Inspection shall be in accordance with 4.8.16.2.

3.10.2.2.1 Minimum contrast requirements. Displays shall meet the high ambient daylight contrast requirements of Table II. Distinct contrast levels, are required for each of the following information categories: (1) numeric information only, (2) alphanumeric information only, (3) graphic information (including alphanumerics as part of its imagery) only and (4) video information. Inspection shall be in accordance with 4.8.16.2.1

3.10.2.2.2 Compensation multipliers. In the event the spatial characteristics of the imagery do not satisfy the image characteristic constraints stipulated in Table II, the contrast requirements in the table shall be modified prior to use using the contrast compensation multipliers of Table II.

3.10.2.2.3 Minimum difference luminance. Displays shall produce the minimum difference luminance output (ΔL_{21} and ΔL_{23}) of not less than 100 fL for numeric, alphanumeric and graphic information image elements and not less than 160 fL for video information image elements. Inspection shall be in accordance with 4.8.16.2.2.

3.10.3 Night operations. During night operations, the lighting system shall provide the aircrew members with a capability to rapidly and accurately obtain required crewstation information with unaided eye vision. The lighting system shall not have an adverse effect on external unaided night vision or on the aircrew's capability to obtain required information external to the aircraft while employing NVIS.

3.10.4 Environmental operating requirements. The lighting system or component shall meet the environmental operating requirements of the individual equipment specifications and shall be tested in accordance with 4.8.9.

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3.10.5 Electromagnetic interference (EMI). Electromagnetic interference requirements shall be in accordance with MIL-STD-461 as specified in the individual equipment specification. Inspection shall be in accordance with 4.8.10.

3.10.6 Electromagnetic compatibility (EMC). The lighting system shall not degrade the capability of the aircraft to meet the requirements of MIL-E-6051 as specified in the individual equipment specification. Inspection shall be in accordance with 4.8.11.

3.10.7 Luminance and illuminance. Unless otherwise specified, the levels of luminance or illuminance shall be as required in the applicable documents cited herein for each component, system or subsystem. The levels of luminace for those areas not covered in the applicable documents shall be in accordance with Table I. Inspection shall be in accordance with 4.8.12.

3.10.8 Chromaticity. When inspected in accordance with 4.8.13, the color of illuminated information (alphanumeric and symbolic) on instruments, controls, control panels and on illuminated areas in designated crewstation and compartment areas shall be as specified herein for that component. These lighting colors and limits are shown on the chromaticity diagrams in Figure 3 (Appendix A is the equivalent 1931 CIE chromaticity plot) and are designated as "NVIS GREEN A", "NVIS GREEN B", "NVIS YELLOW" and "NVIS RED". Conformance to these colors and color limits is determined by the transformation of the 1931 CIE x and y chromaticity coordinates (see 4.8.13.1, Formulas 4 thru 9) to the 1976 UCS u' and v' chromaticity coordinates (see 4.8.13.1, Formulas 10 and 11). These derived u' and v' chromaticity coordinates for the display and equipment colors are applied in the following formula:

$$(u' - u'_1)^2 + (v' - v'_1)^2 \leq (r)^2 \qquad \text{(Formula 1)}$$

Where:

u' and v' = 1976 UCS chromaticity coordinates of the test article.

u'_1 and v'_1 = 1976 UCS chromaticity coordinates of the center point of the specified color area.

r = radius of the allowable circular area on the 1976 UCS chromaticity diagram for the specified color.

3.10.8.1 Primary lighting chromaticity. The chromaticity of the primary lighting system for instruments, displays, consoles, and checklist and radio control plates shall be as specified in Table VIII. At the luminance level specified in Table VIII, the u' and v' chromaticity coordinate values shall be within the area bounded by a circle as shown in Figure 3. Inspection shall be in accordance with 4.8.13.1.

3.10.8.2 Secondary lighting subsystem chromaticity. The secondary lighting subsystem shall illuminate the instruments, displays, consoles, and checklist and radio control plates with a lighting color as specified in Table VIII. Lighting components shall produce u' and v' chromaticity coordinates within the area bounded by a circle as shown in Figure 3 when energized to produce the luminance level specified in Table VIII measured off a reflectance standard (as defined in Appendix B) illuminated in accordance with 4.8.13.2 and 4.8.13.9 (when applicable). Inspection shall be in accordance with 4.8.13.2 and 4.8.13.9 (when applicable).

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3.10.8.3 Illuminated control chromaticity. Control lighting color shall be as specified in Table VIII. At the luminance level specified in Table VIII the u' and v' chromaticity coordinate values shall be within the area bounded by a circle as shown in Figure 3. Inspection shall be in accordance with 4.8.13.3.

3.10.8.4 Compartment lighting chromaticity. Compartment lighting color shall be as specified in Table VIII. Lighting components shall produce u' and v' chromaticity coordinates within the area bounded by a circle as shown in Figure 3 when energized to produce the luminance level specified in Table VIII measured off a reflectance standard surface (as defined in Appendix B) illuminated in accordance with 4.8.13.4 and 4.8.13.9 (when applicable). Inspection shall be in accordance with 4.8.13.4.

3.10.8.5 Utility, work and inspection light chromaticity. Utility, work and inspection lighting color shall be as specified in Table VIII. Lighting components shall produce u' and v' chromaticity coordinates within the area bounded by a circle as shown in Figure 3 when energized to produce the luminance level specified in Table VIII measured off a reflectance standard surface (Appendix B) illuminated in accordance with 4.8.13.2 and 4.8.13.9 (when applicable). Inspection shall be in accordance with 4.8.13.5.

3.10.8.6 Caution and advisory lights chromaticity. Caution and advisory lighting color shall be as specified in Table VIII. At the luminance level specified in Table VIII the u' and v' chromaticity coordinate values shall be within the area bounded by a circle as shown in Figure 3. Inspection shall be in accordance with 4.8.13.6.

3.10.8.7 Jump light chromaticity. The color of jump lights shall be as specified in Table VIII. At the luminance level specified in Table VIII the u' and v' chromaticity coordinate values shall be within the area bounded by a circle as shown in Figure 3. Inspection shall be in accordance with 4.8.13.7.

3.10.8.8 Warning and master caution signal chromaticity.

3.10.8.8.1 Warning signal chromaticity. Warning signal lighting color shall be either "NVIS yellow" or "NVIS Red" in accordance with Table VIII as specified by the acquiring activity (see 6.2.n). At the luminance level specified in Table VIII the u' and v' chromaticity coordinate values shall be within the area bounded by the spectrum locus and a circle, as shown in Figure 3. Inspection shall be in accordance with 4.8.13.8.

3.10.8.8.2 Master caution signal chromaticity. Unless otherwise specified by the acquiring activity (see 6.2.o), the lighting color for the master caution signal shall be as specified in Table VIII. At the luminance level specified in Table VIII the u' and v' chromaticity coordinate values shall be within the area bounded by the spectrum locus and a circle, as shown in Figure 3. Inspection shall be in accordance with 4.8.13.8.

3.10.9 Spectral radiance limits. All interior lighting in aircraft where crewmembers must utilize NVIS to perform their tasks shall be designed to limit spectral radiance as specified in Table IX and herein. Inspection shall be in accordance with 4.8.14.

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3.10.9.1 Primary lighting radiance. The spectral radiance output of primary lighting shall be such that the NVIS radiance (see 6.5.8) shall be as specified in Table IX at the luminance levels specified in Table IX. These components shall include displays and instruments, display consoles, and checklist and radio control plates. Inspection shall be in accordance with 4.8.14.1.

3.10.9.2 Secondary lighting subsystem radiance. The spectral radiance output of the secondary lighting subsystem shall be such that the NVIS radiance shall be as specified in Table IX when energized to produce the luminance level specified in Table IX measured off a reflectance standard surface (as defined in Appendix B) illuminated in accordance with 4.8.14.2 and 4.8.14.11 (when applicable). Illuminated components shall include displays and instruments, consoles, and checklist and radio control plates. Inspection shall be in accordance with 4.8.14.2 and 4.8.14.11 (when applicable).

3.10.9.3 Illuminated control radiance. The spectral radiance output of illuminated controls shall be such that the NVIS radiance shall be as specified in Table IX at the luminance level specified in Table IX. Inspection shall be in accordance with 4.8.14.3.

3.10.9.4 Compartment light radiance. The spectral radiance output of compartment lights shall be such that the NVIS radiance shall be as specified in Table IX when energized to produce the luminance level specified in Table IX measured off a reflectance standard surface (as defined in Appendix B) illuminated in accordance with 4.8.14.4 and 4.8.14.11 (when applicable) Inspection shall be in accordance with 4.8.14.4.

3.10.9.5 Utility, work and inspection lighting radiance. The spectral radiance output of utility, work and inspection lights shall be such that the NVIS radiance shall be as specified in Table IX when energized to produce the luminance level specified in Table IX measured off a reflectance standard surface (as defined in Appendix B) illuminated in accordance with 4.8.14.2 and 4.8.14.11 (when applicable). Inspection shall be in accordance with 4.8.14.5.

3.10.9.6 Caution and advisory light radiance. The spectral radiance output of caution and advisory lights shall be such that the NVIS radiance shall be as specified in Table IX at the luminance level specified in Table IX. Inspection shall be in accordance with 4.8.14.6.

3.10.9.7 Jump light radiance. The spectral radiance output of jump lights shall be such that the NVIS radiance shall be as specified in Table IX at the luminance level specified in Table IX. Inspection shall be in accordance with 4.8.14.7.

3.10.9.8 Warning and master caution signal and emergency exit lighting radiance. The NVIS radiance output of warning and master caution signals and emergency exit lighting shall be as specified in Table IX at the luminance levels specified in Table IX. If these signals have supplementary auditory signals the NVIS radiance may be less than that specified in Table IX. Inspection shall be in accordance with 4.8.14.8.

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3.10.9.9 Electronic and electro-optical display radiance.

3.10.9.9.1 Monochromatic display radiance. Monochromatic electronic and electro-optical displays except Head Up Display (HUD) systems (see 3.10.9.10) that are required to display shades of gray imagery shall have a spectral radiance output such that the NVIS radiance shall be as specified in Table IX at the luminance level specified in Table IX. Inspection shall be in accordance with 4.8.14.9.

3.10.9.9.2 Multi-Color display radiance. The spectral radiance output of any color generated by multi-color electronic and electro-optical displays shall be such that the NVIS radiance is not greater than the "Maximum" NR specified for multicolor displays in Table IX at the specified luminance level. In addition, the closest producible color to the 1976 UCS chromaticity point u' = .1704, v' = .4042 shall have a spectral radiance such that the NVIS radiance is not greater than the "White" specified in Table IX at the luminance level specified in Table IX. Inspection shall be in accordance with 4.8.14.9.

3.10.9.10 HUD system radiance. For HUD systems, the spectral radiance output shall be such that the NVIS radiance shall be as specified in Table IX at the luminance level specified in Table IX. Inspection shall be in accordance with 4.8.14.10.

3.10.10 Light leaks. In addition to the requirements of the individual equipment specification, lighting components shall not exhibit light leakage (see 6.5.10.). Inspection shall be in accordance with 4.8.15.

3.10.11. Luminance uniformity. At any given luminance level, lighting components within a lighting subsystem shall provide luminance such that the average luminance ratio between lighted components shall be not greater than 2 to 1. Inspection shall be in accordance with 4.8.5.

3.10.12 Crewstation reflections. When inspected in accordance with 4.8.6, crewstation reflections shall be as stated herein. Reflections from the canopy and windshields and side windows shall be minimized. Reflections which affect the outside vision of the aviator wearing NVIS shall not be permitted. Specular reflections resulting from aircraft lighting sources shall not occur within the area subtended by a solid angle of one steradian centered at the pilot's design eye position and along the pilot's horizontal vision line. The pilot's design eye position and horizontal vision line are defined in MIL-STD-1333 for U.S. Navy and U.S. Army aircraft and MIL-STD-1776 for U.S. Air Force aircraft.

3.11 Human engineering. The human engineering requirements of MIL-STD-1472 for visual displays, aural displays, labeling, anthropometry, workspace design, design for maintainability, and aerospace vehicle compartment design shall apply in the design of the NVIS compatible interior lighting system. In the event of conflict between MIL-STD-1472 and this specification, this specification shall take precedence. Inspection shall be in accordance with 4.8.4.

3.12 System safety. When specified by the acquiring activity (see 6.2.p), a system safety program as outlined in MIL-STD-882 shall be conducted.

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3.13 Reliability and maintainability. Reliability and maintainability requirements shall be in accordance with the individual equipment specification.

3.13.1 Maintenance Trimming controls. Trimming capability for each primary instrument and control panel lighting component shall be provided to permit the establishment and maintenance of balanced instrument panel lighting. These adjustment controls shall be located in a readily accessible but noncritical crewstation area.

4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or order, the contractor may use his own or other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items shall meet all requirements of sections 3 and 5. The inspections set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling inspection as part of manufacturing operations, is an acceptable practice to ascertain conformance to requirements, however, this does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to accept defective material.

4.1.2 Test equipment and inspection facilities. The contractor shall insure that test and inspection facilities of sufficient accuracy, quality, and quantity are established and maintained to permit performance of required inspections.

4.2 Classification of inspections. The inspection requirements specified herein are classified as follows:

a. Mockup inspection (see 4.3).

b. First article inspection (see 4.4).

c. Quality conformance inspection (see 4.5).

4.3 Mockup inspection. When specified by the acquiring activity (see 6.2.g), a mockup inspection shall be conducted (see 3.4). The mockup inspection shall consist of all of the examinations and tests specified in Table III not necessarily in the order listed.

4.4 First article inspection. The first article inspection shall consist of the examinations and tests specified in the individual equipment specification in addition to those specified in Table IV not necessarily in the order listed.

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4.4.1 First article samples. Unless otherwise specified, as soon as practicable after award of the contract or order, the contractor shall submit first article samples as required by the contract or order (see 6.2.e). The samples shall be representative of the construction, workmanship and materials to be used during production. When a contractor is in continuous production of these systems or components from contract to contract, submission of further first article samples may be waived at the discretion of the acquiring activity (see 6.2.d). Approval of the first article samples or the waiving of first article inspection does not preclude the requirement of submitting to the quality conformance inspection. The first article inspection samples shall be furnished to the first article inspection laboratory as directed by the contracting officer (see 6.2.f). The samples shall be plainly marked with the following information:

> Samples submitted by (name) (date) for first article inspection in accordance with the requirements of MIL-L-85762A Type () Class () under Contract No.

4.4.1.1 First article information. Upon completion of the first article inspection, all the applicable inspection reports, and when applicable, recommendations and comments pertinent for use in monitoring production shall be made available to the cognizant activity (see 6.2 and 6.4). One approved first article sample may be returned to the contractor for use in monitoring production. Remaining samples which are approved and pass first article inspection may be delivered as part of the quantity to be delivered under contract.

4.5 Quality conformance inspection. Quality conformance inspection shall consist of the examinations and tests as specified in the individual equipment specification in addition to those specified in Table V. The sampling and inspection levels shall be as specified in the individual equipment specification.

4.5.1 Quality conformance sampling. Samples to be subjected to quality conformance inspection shall be made essentially under the same conditions and from the same materials.

4.6 Test data. When specified in the contract or order (see 6.3) the contractor shall provide spectroradiometric and photometric test data for each tested sample(s) as required.

4.7 Inspection conditions.

4.7.1 Atmospheric conditions. Unless otherwise specified in the individual equipment specification, all inspections herein shall be performed at atmospheric pressure of 28 to 32 inches Hg at a temperature of 21° ± 3°C, and a relative humidity of 80% or less.

4.7.2 Order of inspection. All inspections shall be performed after the environmental inspections required by the individual equipment specification.

4.7.3 Lighting conditions. Luminance, chromaticity and radiance measurements shall be made in a dark room where the ambient special radiant energy over the spectral range of 380 through 930 nanometers is either unmeasureable (equivalent to system noise) or no greater than 1% of the value of spectral radiant energy from the test sample being measured.

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4.7.3.1 Test set up verification. With all the equipment positioned in the darkroom as they would be for test measurements, focus the spectroradiometer on a reflectance standard meeting the requirements of Appendix B located in place of the test sample and, with the room in a darkened condition, measure the ambient radiant energy incident on the reflectance standard. The data obtained shall be kept on file and shall be compared with data subsequently developed from all test samples to verify compliance with the requirements of 4.7.3. This verification procedure shall be repeated when the darkroom ambient spectral radiant energy levels become suspect or at six month intervals, whichever occurs first.

4.7.4 Test set up. Stray light from the test lighting component shall be controlled so that it is not reflected, refracted, or scattered into the measuring equipment.

4.8 Inspection methods and procedures.

4.8.1 Lighting system unaided eye inspection. During the mockup inspection of 3.4, each lighting subsystem (primary instrument panel, secondary instrument panel, primary console, secondary console, warning, caution and advisory signals, utility, and compartment) shall first be subjected to an unaided eye inspection at the lighting levels specified in the applicable documents of 3.4. This inspection shall then be repeated at the NVIS compatible lighting levels specified in Table IX. Nonconformance to 3.4 shall constitute failure of this test.

4.8.2 Lighting system NVIS compatible examination. During the mockup inspection of 3.4, each lighting subsystem, (primary instrument panel, secondary instrument panel, primary console, secondary console, warning, caution and advisory signal, utility, and compartment) when set at the NVIS compatible lighting levels specified in Table IX shall be subjected to examination while utilizing NVIS to verify compatibility with the NVIS and to identify any source of light leakage from the lighting subsystems.

4.8.2.1 Cockpit mockup set-up. With all mockup lighting subsystems extinguished, place a USAF 1951 medium contrast resolution resolving power target as specified in MIL-STD-150 outside the aircraft mockup. The resolution target shall be irratiated so that the NVIS radiance from the white portions of the resolution target equals 1.7×10^{-10} NR_A for Class A requirements, and 1.6×10^{-10} NR_B for Class B requirements. The distance of the resolution target from the mockup shall be such that an observer wearing a NVIS within the aircraft mockup looking at the target irratiated as specified above is just capable of resolving an element in a target group midway between the largest and smallest target groups on the resolution chart. Care shall be taken to locate the resolution target so that aircraft lighting subsystems, when energized, do not illuminate the resolution target. The position of the resolution target shall be subject to approval by the acquiring activity.

4.8.2.2 Examination. Operate the various lighting subsystems singly and in combination with the other lighting subsystems, individually, and as a group. Using NVIS, verify that the lighting subsystems do not adversely affect the ability of the observer to resolve the target element on the resolution chart previously

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selected in 4.8.2.1. Scan the lighting subsystems to identify any light leaks. Perform any other examinations which demonstrate lighting subsystem conformance to the NVIS compatibility requirements of this specification. Nonconformance to 3.4 shall constitute failure of this test.

4.8.3 Design, location and actuation inspection. During the mockup inspection each installed lighting component, system, and subsystem shall be subject to visual inspection. Nonconformance to the design, location and actuation requirements of this specification, MIL-STD-203, or MIL-STD-250, shall constitute failure of this inspection.

4.8.4. Human engineering inspection. During the mockup inspection each installed lighting component, system, and subsystem shall be inspected visually for human engineering or human performance criteria. Nonconformance to 3.11 shall constitute failure of this inspection.

4.8.5 Luminance uniformity.

4.8.5 1 Low level. During the mockup inspection, each lighting subsystem shall be energized independently to one half of the rated drive condition. A visual inspection shall be made to determine the brightest and dimmest lighting component of that subsystem. Unless visual inspection has been accepted for luminance uniformity by the acquiring activity, a photometer in accordance with Appendix B shall be used to measure the luminance of the brightest and dimmest lighting component. Nonconformance to 3.10.11 shall constitute failure of this test.

4.8.5.2 High level. Each lighting subsystem shall then be energized independently to maximum brightness. A visual inspection shall be made to determine the brightest and dimmest component of that subsystem. A photometer in accordance with Appendix B shall be used to measure the luminance of the brightest and dimmest lighting component. Nonconformance to 3.10.11 shall constitute failure of this test.

4.8.6 Crewstation reflections. Examination for specular reflections shall be performed during the mockup inspection (see 4.8.2). Nonconformance to 3.10.12 shall constitute failure of this test.

4.8.7 Visual examination. Each lighting system, subsystem, or component shall be examined visually to determine conformance with this specification. Any evidence of foreign matter, cracks, scratches, bubbles, delamination, warps or stray light shall be considered cause for rejection.

4.8.8 Operation. Each lighting system, subsystem, or component to be inspected shall be energized as specified in 3.9.4 to determine that it operates in accordance with this specification.

4.8.9 Environmental operating tests. Each lighting system, subsystem, or component shall be tested in accordance with the environmental operating test criteria of the individual equipment specification.

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4.8.10 Electromagnetic interference (EMI) tests. EMI tests shall be performed in accordance with MIL-STD-462. Nonconformance to 3.10.5 shall constitute failure of this test.

4.8.11 Electromagnetic compatibility (EMC) tests. EMC test shall be performed in accordance with MIL-E-6051. Nonconformance to 3.10.6 shall constitute failure of this test.

4.8.12 Luminance and illuminance measurements. Unless otherwise specified herein, luminance and illuminance measurements shall be performed in accordance with the individual equipment specification for the applicable lighting component. Luminance or illuminance measurements shall be performed by using either a spectroradiometer or photometer meeting the requirements of Appendix B. When a spectroradiometer, meeting the requirements of Appendix B is used to measure luminance or illuminance, the luminance or illuminance shall be calculated using the following standard formulas. Nonconformance to 3.10.7 shall constitute failure of this test.

$$L = 929\pi K(\lambda)_{max} \int_{380}^{780} K(\lambda)N(\lambda)d\lambda \qquad \text{(Formula 2)}$$

$$E_v = 929K(\lambda)_{max} \int_{380}^{780} K(\lambda)E_e(\lambda)d\lambda \qquad \text{(Formula 3)}$$

Where:

L = luminance (footlamberts) or

E_v = illuminance (footcandles)

$K(\lambda)$ = normalized visual efficiency curve for 1931 standard observer

$K(\lambda)_{max}$ = 683 lm/W

$N(\lambda)$ = spectral radiance of lighting component (W/cm^2sr nm)

$E_e(\lambda)$ = flux density incident (W/cm^2)

$d\lambda$ = 5 nm

4.8.13 Chromaticity measurements.

4.8.13.1 Primary lighting chromaticity measurements. Chromaticity measurements shall be made in a dark room meeting the requirements of 4.7.3. Depending on the type of lighting component being evaluated, the drive condition shall be applied to the lighting component(s) necessary to achieve the luminance level of Table VIII for the applicable component. The luminance shall be measured using either a spectroradiometer or photometer meeting the requirements specified in Appendix B.

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With the specified luminance achieved, the spectral output of the lighting component shall be measured with a spectroradiometer which meets the requirements of Appendix B. Each spectral measurement shall be made using the actual aircraft lighting source, filter, and fixture. The spectroradiometer shall be placed a distance from the device being tested so that several numbers, letters, or indicia are included within the spectroradiometer test field. The x and y 1931 C.I.E. and the u' and v' 1976 UCS chromaticity coordinate points shall then be calculated using the following formulas. Nonconformance to 3.10.8.1 shall constitute failure of this test.

$$N(\lambda) = I(\lambda)/R(\lambda) \qquad \text{(Formula 4)}$$

$$X = \int_{380}^{780} \bar{x}\, N(\lambda)\, d\lambda \qquad \text{(Formula 5)}$$

$$Y = \int_{380}^{780} \bar{y}\, N(\lambda)\, d\lambda \qquad \text{(Formula 6)}$$

$$Z = \int_{380}^{780} \bar{z}\, N(\lambda)\, d\lambda \qquad \text{(Formula 7)}$$

$$x = \frac{X}{X + Y + Z} \qquad \text{(Formula 8)}$$

$$y = \frac{Y}{X + Y + Z} \qquad \text{(Formula 9)}$$

$$u' = \frac{4x}{-2x + 12y + 3} \qquad \text{(Formula 10)}$$

$$v' = \frac{9y}{-2x + 12y + 3} \qquad \text{(Formula 11)}$$

Where:

$N(\lambda)$ = spectral radiance of the lighting component (W/cm^2 sr nm or normalized)

$I(\lambda)$ = detector current (amperes)

$R(\lambda)$ = spectroradiometer spectral sensitivity (amperes cm^2 sr nm/W)

$d\lambda$ = 5 nm

$\bar{x}$ = 1931 C.I.E. relative spectral response of the eye (color matching function)

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$\bar{y}$ = 1931 C.I.E. relative spectral response of the eye (color matching function)

$\bar{z}$ = 1931 C.I.E. relative spectral response of the eye (color matching function)

X = C.I.E. tristimulus value

Y = C.I.E. tristimulus value

Z = C.I.E. tristimulus value

u' = 1976 UCS chromaticity coordinate transformation of CIE x

v' = 1976 UCS chromaticity coordinate transformation of CIE y

x = 1931 C.I.E. chromaticity coordinate

y = 1931 C.I.E. chromaticity coordinate

4.8.13.2 Secondary lighting chromaticity measurements. For chromaticity measurements the appropriate drive condition shall be applied to the light being tested (test light) to illuminate a reflectance standard meeting the requirements of Appendix B, to a luminance level of 0.1 fL at a distance of 12 inches. The test light shall be oriented perpendicular to the reflectance standard. The spectroradiometer shall be set up such that the reflectance standard is at a 45° angle with the line of sight of the spectroradiometer. The spectral radiance of the reflectance standard shall be measured using an aperture that is as large as possible within the projected area of the reflectance standard. The corrected spectral radiance shall then be calculated using the following formula.

$$N(\lambda) = \frac{M(\lambda)}{r(\lambda)} \qquad \text{(Formula 12)}$$

Where:

$N(\lambda)$ = corrected spectral radiance (W/cm^2 sr nm)

$M(\lambda)$ = measured spectral radiance of the reflectance standard (W/cm^2 sr nm)

$r(\lambda)$ = reflectance of the reflectance standard

The chromaticity of the test light shall be calculated using the corrected spectral radiance and the formulas given in 4.8.13.1. Nonconformance to 3.10.8.2 shall constitute failure.

4.8.13.3 Illuminated control chromaticity measurements. Inspection shall be in accordance with 4.8.13.1. Nonconformance to 3.10.8.3 shall constitute failure.

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4.8.13.4 Compartment lighting chromaticity measurements. The chromaticity inspection for compartment lighting shall be the same as for secondary lighting (4.8.13.2) except that the distance between the test light and the reflectance standard shall be adjusted to be equivalent to the distance at which the lighting component will be used when installed in an aircraft. Nonconformance to 3.10.8.4 shall constitute failure.

4.8.13.5 Utility, work and inspection lighting chromaticity measurements. Inspection shall be the same as for secondary lighting (4.8.13.2) Nonconformance to 3.10.8.5 shall constitute failure.

4.8.13.6 Caution and advisory light chromaticity measurements. Inspection shall be in accordance with 4.8.13.1. Nonconformance to 3.10.8.6 shall constitute failure.

4.8.13.7 Jump light chromaticity measurements. Inspection shall be in accordance with 4.8.13.1. Nonconformance to 3.10.8.7 shall constitute failure.

4.8.13.8 Signal indicator chromaticity measurements. Inspection shall be in accordance with 4.8.13.1. Nonconformance to 3.10.8.8 shall constitute failure.

4.8.13.9 Floodlighted instrument, console and panel chromaticity measurements. The chromaticity of instruments, consoles and panels intended to be floodlighted shall be in accordance with 4.8.13.2 except that the instrument console or panel shall be floodlighted to the specified luminance levels by the same type of light that will be used when the panel is installed in the aircraft. Nonconformance to 3.10.8 shall constitute failure.

4.8.14 Spectral radiance measurements.

4.8.14.1 Primary lighting spectral radiance measurements. NVIS radiance measurements shall be made in a dark room meeting the requirements of 4.7.3. Power shall be applied to the lighting component in such a manner that the luminance at the rated drive condition or 15.0 fL, whichever is less, is achieved. The luminance shall be measured using either a spectroradiometer or photometer meeting the requirements specified in Appendix B. With the appropriate luminance achieved, a spectroradiometer which meets the requirements of Appendix B shall be set up to measure the spectral radiance. The aperature selected for measurement shall provide spectroradiometer sensitivity in accordance with B30.2. If the size of numerals, lettering or indicia permit, the spectroradiometer shall be set up to measure at least three different areas on the device. If size does not permit spectral radiance measurements of individual numerals, lettering or indicia, the spectral radiance shall be measured by including several numeral(s), lettering, and indicia within the spectroradiometer test field. The NVIS radiance shall be calculated using the appropriate formulas herein. Nonconformance to 3.10.9 shall constitute failure of this test. A scaling factor shall be generated using the following formula:

$$S = \frac{L_r}{L_m} \qquad \text{(Formula 13)}$$

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Where:

S = scaling factor

L_r = required luminance level for NVIS radiance (see Table IX)

L_m = luminance measured by the spectroradiometer

Formula 14a shall be used to calculate the NVIS radiance of Class A equipment. Formula 14b shall be used to calculate the NVIS radiance of Class B equipment.

$$\text{NVIS radiance } (NR_A) = G(\lambda)_{max} \int_{450}^{930} G_A(\lambda) SN(\lambda) d\lambda \quad \text{(Formula 14a)}$$

$$\text{NVIS radiance } (NR_B) = G(\lambda)_{max} \int_{450}^{930} G_B(\lambda) SN(\lambda) d\lambda \quad \text{(Formula 14b)}$$

Where:

$G_A(\lambda)$ = relative NVIS response of Class A equipment (see Table VI)
$G_B(\lambda)$ = relative NVIS response of Class B equipment (see Table VII)
$N(\lambda)$ = spectral radiance of lighting component (W/cm^2 sr nm)
S = scaling factor
$G(\lambda)_{max}$ = 1 mA/W
$d\lambda$ = 5 nm

4.8.14.2 Secondary lighting radiance measurements. For NVIS radiance measurements the appropriate drive condition shall be applied to the test light to illuminate the reflectance standard such that the luminance requirement of Table IX is met at a distance of 12 inches. The test light shall be oriented perpendicular to the reflectance standard. The spectroradiometer shall be set up such that the reflectance standard is at a 45° angle with the line of sight of the spectroradiometer. The spectral radiance of the reflectance standard shall be measured. The corrected spectral radiance shall then be calculated using formula (12) and the NVIS radiance shall be calculated using the corrected spectral radiance and the formulas in 4.8.14.1. Nonconformance to 3.10.9.2 shall constitute failure.

4.8.14.3 Illuminated control radiance measurements. Inspection shall be in accordance with 4.8.14.1. Nonconformance to 3.10.9.3 shall constitute failure.

4.8.14.4 Compartment lighting radiance measurements. The NVIS radiance inspection for compartment lighting shall be the same as for secondary lighting (4.8.14.2) except that the distance between the test light and the reflectance standard shall be adjusted to be equivalent to the distance at which the lighting component will be used when installed in an aircraft. Nonconformance to 3.10.9.4 shall constitute failure.

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4.8.14.5 Utility, work and inspection lighting radiance measurements. Inspection shall be the same as for secondary lighting (4.8.14.2). Nonconformance to 3.10.9.5 shall constitute failure.

4.8.14.6 Caution and advisory light radiance measurements. Inspection shall be in accordance with 4.8.14.1. Nonconformance to 3.10.9.6 shall constitute failure.

4.8.14.7 Jump light radiance measurements.. Inspection shall be in accordance with 4.8.14.1. Nonconformance to 3.10.9.7 shall constitute failure.

4.8.14.8 Signal indicator radiance measurements. Inspection shall be in accordance with 4.8.14.1. Nonconformance to 3.10.9.8 shall constitute failure.

4.8.14.9 Electronic and electro-optical display radiance measurements. Inspection shall be in accordance with 4.8.14.1. The acquiring activity shall specify the number and type of colors or composite colors that shall be measured (see 6.2.q). The spectroradiometer shall be placed so that as much of the display as reasonably possible is within the spectroradiometer test field. Nonconformance to 3.10.9.9 shall constitute failure.

4.8.14.10 HUD system radiance measurements. Inspection shall be in accordance with 4.8.14.1 and as stated herein. If the display is unable to generate the luminance level specified in Table IX relative spectral radiance shall be measured at the display's maximum luminance level and scaled to the specified luminance level. Nonconformance to 3.10.9.10 shall constitute failure.

4.8.14.11 Floodlighted instrument, console and panel radiance measurements. The NVIS radiance inspection of instruments, consoles and panels intended to be floodlighted shall be in accordance with 4.8.14.1 except that the instrument console or panel shall be floodlighted to the specified luminance levels by the same type of light that will be used when the panel is installed in the aircraft. Nonconformance to 3.10.9 shall constitute failure.

4.8.15 Light leak inspection. The lighting component, system, or subsystem shall be illuminated as specified and examined thru the NVIS for evidence of light leakage. Nonconformance to 3.10.10 shall constitute failure.

4.8.16 Daylight legibility and readability inspection.

4.8.16.1 Illuminated visual signals.

a. Illuminated visual signals requiring readability in direct reflected specular sunlight shall be inspected in accordance with the sunlight readability test procedures described in MIL-S-22885 . Nonconformance to 3.10.2.1 shall constitute failure.

b. Illuminated visual signals not requiring readability in direct reflected specular sunlight shall be inspected in accordance with the sunlight readability test procedures of MIL-S-38039. Nonconformance to 3.10.2.1 shall constitute failure.

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4.8.16.2 Monochrome electronic and electro-optical display inspection. Inspection shall be as specified herein. Light sources used for legibility and readability testing shall have a color temperature of not less than 3000°K and not greater than 6500°K.

4.8.16.2.1 Minimum contrast measurements. The following display luminance quantities shall be measured in the ambient lighting conditions specified in 3.10.2.2 using the techniques specified herein.

L_1, the average background luminance of the display surface in areas adjacent to and therefore visually contrasted with activated display image elements.

L_2, the average luminance of activated display image elements.

L_3, the average luminance of deactivated display image elements.

An image element consists of the spatially distinguishable portions of displayed characters, symbols or video image patterns which must as a minimum be visually discriminated to make the display information recognizable to an observer (i.e. it consists of as a minimum one, but more typically several display picture elements). Using these measured luminance values, L_1, L_2, and L_3, three contrasts (C_L, C_I and C_{UL}) shall be calculated employing the following equations (see 6.5.11). Nonconformance to 3.10.2.2.1 shall constitute failure.

$$C_L = \frac{L_2-L_1}{L_1} = \frac{\Delta L_{21}}{L_1} \qquad \text{(Formula 15)}$$

Where: C_L = the ON/BACKGROUND contrast of a lighted (or activated) display image element

$$C_I = \frac{L_2-L_3}{L_3} = \frac{\Delta L_{23}}{L_3} \qquad \text{(Formula 16)}$$

Where: C_I = the ON/OFF contrast of a display image element

$$C_{UL} = \frac{L_3-L_1}{L_1} = \frac{\Delta L_{31}}{L_1} \qquad \text{(Formula 17)}$$

Where: C_{UL} = the OFF/BACKGROUND contrast of an unlighted (or deactivated) display image element

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4.8.16.2.2 Luminance measurements. To measure L_1, L_2 and L_3, with which to calculate contrast (formulas 15 thru 17), the direct area average measurement technique of 4.8.16.2.2.1 or the indirect area averaged measurement technique of 4.8.16.2.2.2 shall be used. If the image elements are large enough to permit several nonoverlapping measurements to be made within the image element boundaries (e.g. for numeric readout segments) luminance readings spaced nominally one sensor aperture diameter apart shall be taken and averaged to establish the image element luminance. The average luminance of display image elements in a minimum of five spatially distributed areas of the display surface shall be determined. Nonconformance to 3.10.2.2.1 thru 3.10.2.2.3 shall constitute failure. If it can be demonstrated that the difference luminance terms do not change under high ambient illuminance or that they change in a predictable manner, the luminance terms L_1, L_2 and L_3 used to calculate the difference luminance values may at the option of the test activity be measured in low or medium ambient illuminance test conditions to improve the accuracy of the measurements. The same luminance sensing aperture size shall be used to measure L_2 and L_3. Nonconformance to 3.10.2.2 thru 3.10.2.2.3 shall constitute failure.

4.8.16.2.2.1 Direct area average measurements. A photometer which measures an area that subtends an angle of 1.8 minute or more of arc at the intended pilot to display viewing distance shall be used to make the luminance measurements.

4.8.16.2.2.2 Indirect area averaged measurements. If a photometer with a sensing area smaller than that specified in 4.8.16.2.2.1 is used, a sufficient number of luminance readings shall be taken to permit determining the average luminance over the area of the 1.8 minute or more of arc diameter sensing aperture. Within this aperture, both active and inactive areas of the display surface shall be averaged. Positioning of this measurement aperture within the area of an image element to achieve maximum readings is permissible.

4.8.16.2.3 Reflected luminance measurements. The terms L_1, L_2 and L_3 in the contrast equations (formulas 15 thru 17) shall include the combined effects of both specular, and diffuse, reflected luminance contributions. The measurements may be made using either a two light source configuration capable of simultaneously inducing both the specular and the diffuse reflected luminance contributions, as illustrated in Figure 4, or through separate measurements using one source at a time and summing the specular and diffuse reflected luminance contributions.

4.8.16.2.3.1. Diffuse reflected luminance measurements. The illuminance source E_1 in Figure 4 shall be positioned on the display's axis perpendicular to the display face. The diffuse reflected luminance shall be measured by the photometer, P, which is oriented at an angle, $\theta_P = 30 \pm 2°$ with respect to n. The photometer shall be focused to produce a clear measurement spot at the display surface. With a white diffuse reflecting standard surface (barium sulfate or equivalent) substituted for the display surface, the source, E_1, shall be adjusted to produce 10,000fL. The white reflectance standard surface shall then be removed and replaced by the display

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surface to be measured. The display shall be translated with a combination of X and Y display motions (see Figure 4) to measure L_1, L_2 and L_3. A luminance measuring aperture larger than that used to measure L_2 and L_3 may, if desired, be used to measure L_1. If the values of the difference luminances ΔL_{21} and ΔL_{23} must be established under high ambient illuminance (see 4.8.16.2.2), the diffuse reflectance test condition above shall be used. If the option to measure the display difference luminance in lower ambient illumination conditions has been justified in accordance with 4.8.16.2.2, the measurement of L_2 may be omitted in this procedure. Subject to the approval of the acquiring activity, diffuse reflected luminance readings taken normal to the display surface using an integrating sphere, with its internal surface reflected luminance adjusted to 10,000 fL, may be substituted for the spot source procedure just described.

4.8.16.2.3.2 Specular reflected luminance measurements. The surface labeled, L, in Figure 4 oriented at an angle $\theta_L=\theta_P$, produces a luminance which when mirrored by the display surface can be sensed by the photometer, P, as a defocused image (i.e. the photometer remains focused on the display surface as the viewers' eyes would when using the display). The luminous surface, L, may be a light source, a transilluminated surface or as illustrated in Figure 4, a diffuse light reflecting surface illuminated by the light source labled E. With a mirror substituted for the display surface, the photometer, the light source and the mirror shall be oriented to achieve an angular relationship such that $\theta_P=\theta_L=30°$ and to simultaneously permit filling an area in the photometer measurement field surrounding the measurement spot that is at least three times the apparent diameter of the spot, or the entire photometer viewing field, whichever is smaller. The luminance of the source, L, shall then be adjusted to 2,000 fL as measured by the photometer focused at the mirror surface. Replace the mirror surface with the display surface. Measure the luminances specularly reflected by the display surface, or by any intervening display optical filter elements. The display shall then be translated as previously described to permit image background luminance measurements, and off image luminance measurements. The specular test procedure just described should produce some diffuse illumination on the display, but this is normally less than 100 fc and may be ignored relative to the 10,000 fc used in the diffuse test.

5. PACKAGING

5.1 This section is not applicable to this specification.

6. NOTES

(This section contains information of general or explanatory nature that may be helpful, but is not mandatory.)

6.1 Intended use. The lighting requirements specified herein are intended to cover all of the aircraft interior lighting of equipment areas, crewstations and compartments in which aircrew members must perform their duties while wearing NVIS.

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6.2 Acquisition requirements. Acquisition documents must specify the following:

a. Title, number and date of this specification.
b. Type, class and quantity desired.
c. Issue of DODISS to be cited in the solicitation, and if required the specific issue of individual documents referenced (see 2.2).
d. Whether first article inspection is required or waived (see 3.3 and 4.4.1).
e. Number of first article samples required (see 4.4.1).
f. Name and address of the first article inspection laboratory (see 4.4.1).
g. Whether Air Force, Army, or Navy mockup inspection is required or waived (see 3.4 and 4.3).
h. Whether secondary instrument and display lighting is required (see 3.9.10.2).
i. Whether secondary console lighting is required (see 3.9.12.2).
j. Compartment lighting requirements (see 3.9.13).
k. Whether high intensity lighting is required (see 3.9.15).
l. Whether emergency exit lighting is required (see 3.9.16).
m. Whether checklist and radio call plates are required (see 3.9.21).
n. Warning signal color (see 3.10.8.8.1).
o. Master Caution signal lighting color (see 3.10.8.8.2)
p. Whether a system safety program is required (see 3.12).
q. Number and type of colors or composite colors to be inspected for color electronic displays (see 4.8.14.9).

6.3 Consideration of data requirements. The following data requirements should be considered when this specification is applied on a contract. The applicable Data Item Descriptions (DID's) should be reviewed in conjunction with the specific acquisition to ensure that only essential data are requested/ provided and that the DID's are tailored to reflect the requirements of the specific acquisition. To ensure correct contractual application of the data requirements, a Contract Data Requirements List (DD Form 1423) must be prepared to obtain the data, except where DOD FAR Supplement 27.475-1 exempts the requirement for a DD Form 1423.

Reference Para.	DID No.	DID Title
4.4.1.1	DI-T-4901	First Article Inspection Procedure
4.4.1.1	DI-T-4902	First Article Inspection Report
4.6	DI-MISC-80113A	NVIS Compatible Aircraft Interior Lighting Compliance Data

(The above DID's were those cleared as of the date of this specification. The current issue of DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), must be researched to ensure that only current, cleared DID's are cited on the DD Form 1423.)

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6.4 First article. When a first article inspection is required, the item(s) should be a first article sample(s). The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results, number of first article units and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.5 Definitions.

6.5.1 Night Vision Imaging System (NVIS). A system which uses image intensifier tubes to produce an enhanced image of a scene in light conditions too low for normal navigation and pilotage.

6.5.1.1 Direct View Image NVIS (Type I). Any NVIS which uses generation III image intensifier tubes and displays the intensified image on a phosphor screen in the user's direct line of sight. The AN/AVS-6, Aviator's Night Vision Imaging System (ANVIS) is an example of a Type I system.

6.5.1.2 Projected Image NVIS (Type II). Any NVIS which uses generation III image intensifier tubes and projects the intensified image on a see through medium in the user's line of sight. This configuration allows simultaneous viewing of the intensified image and visual cues such as HUD symbology.

6.5.1.3 Class A NVIS. Any NVIS which uses the 625nm filter described by Figure 1. Class A NVIS is not compatible with red cockpit lights because of the overlap between the spectrum of red light and the sensitivity of Class A NVIS.

6.5.1.4 Class B NVIS. Any NVIS which uses the 665nm filter described by Figure 2. A Class B NVIS is compatible with NVIS Red and therefore is compatible with properly filtered red lights and color electronic displays which meet the requirements of Table VIII and IX. When specified in Table IX, certain components are required to meet Class A NVIS compatibility requirements in order to facilitate interchangeability of equipment.

6.5.2 NVIS lighting compatibility The aircraft interior lighting that provides acquisition of aircraft interior information with the unaided eye without degrading the image intensification capabilities of the NVIS during night flight operations. Conformance to the detailed performance and test requirements of the lighting components and systems specified herein shall be considered as meeting this definition.

6.5.3 Lighting system. All devices that emit or transmit light within the flight deck or other crew compartments.

6.5.4 Lighting subsystem. All devices that emit or transmit light within the flight deck or other crew compartments and are attached to the aircraft power via a common dimmer control.

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6.5.5 Crewstation or compartment. All work stations or compartments within the aircraft in which the aircrew member is required to use NVIS in the performance of duties.

6.5.6 Interior lighting All lighting within the aircraft including but not restricted to the following lighting systems:

a. Instrument
   - o Primary
   - o Secondary

b. Console
   - o Primary
   - o Secondary

c. Emergency
d. Warning, caution, and advisory displays and indicators
e. Utility
f. Controls (knobs, handles, push buttons)
g. Compartment
h. Work and inspection lights
i. Jump lights

6.5.7 CIE color coordinate system The fundamental definitions of color are expressed in terms of the "standard observer" and coordinate system adopted by the International Commission on Illumination (C.I.E.) at Cambridge, England, in 1931 and published in the Journal of the Optical Society of America, vol. 23, page 359, October 1933. Wherever chromaticity coordinates (x, y, z) appear in this specification they relate to this system. The CIE 1976 uniform chromaticity scale (UCS) diagram is the CIE 1931 chromaticity diagram redrawn with the x and y axes subjected to a linear transformation as defined in CIE Publication 15, Supplement 2, 1978.

6.5.8 NVIS radiance. NVIS radiance is the amount of energy emitted by a light source that is visible through NVIS. NVIS radiance is defined as the integral of the curve generated by multiplying the spectral radiance of a light source by the relative spectral response of the NVIS defined in Table VI or Table VII as appropriate (see 4.8.14).

6.5.9 Rated drive condition. Rated drive condition(s) are the electrical power state(s) obtained by conformance to the allowable electrical characteristics (voltage, current, pulse width modulation, frequency, etc.) in MIL-STD-704 for the various lighting components or systems in meeting specified lighting levels.

6.5.10 Light leaks. Visual evidence through the NVIS of light emitted from a component from areas which are not intended to be illuminated.

6.5.11 Contrast vs contrast ratio. Contrast (C_L, C_I and C_{UL}) as specified in 4.8.16.2.1 is one less than contrast ratio, defined as L_2/L_1, in some specifications.

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6.6 Rationale Rationale behind the requirements of this specification are available in NADC Report No. 87060-20, Rationale Behind The Requirements Contained in Military Specification MIL-L-85762 and MIL-L-85762A.

6.7 Subject term (keyword) listing.

ANVIS compatible
chromaticity
console
controls
crewstation lighting
daylight readability
direct image NVIS
display
lighting
NVG compatible
NVIS compatible
projected image NVIS
radiance

6.8 Metrication. When metric units are preferred, metrication shall be performed and conform to the practices of FED-STD-376. If metrication is utilized, conformance to all of the requirements of this specification shall be maintained. The following conversion factors are applicable to this specification.

Inches X 25.4 = millimeters (mm)
Foot X 0.3048 = meters (m)
Footlamberts (fL) X 3.426751 = candela per m^2 (cd/m^2) or (NITS)
Footcandles (fc) X 10.76391 = lumens per meter square or lux (lx)

6.9 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue date due to the extensiveness of the changes.

6.10 International standardization agreements. Certain provisions of this specification are the subject of international standardization agreement STANAG No. 3800. When amendment, revision, or cancellation of this specification is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels including departmental standardization offices to change the agreement or make other appropriate accommodations.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Review:
Air Force - 99
DLA - GS

Preparing Activity:
Navy - AS
(Project No. 6220-0355)

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TABLE I. General lighting for crewstations and compartments[1]

	ILLUMINATED LEVEL IN FOOTCANDLES (AT RATED DRIVE CONDITION)	
	MIN	MAX
CREWSTATION AREA, GENERAL ILLUMINATION	1 (Aisle Floor)	20 (Crew lap level)
CONTROL PANELS NOT ILLUMINATED (REQUIRING IN-FLIGHT ADJUSTMENT AND OPERATION)	5	10
INSTRUMENT PANEL AND CONSOLES	2	10
PASSAGEWAYS AND AISLES (ON FLOOR)	0.2	5
CARGO COMPARTMENT (ON FLOOR)	0.2	5
LOADING AND RAMP AREAS (ON FLOOR)	2	10
CREWSTATION LOCATIONS FOR NAVIGATIONAL AND SYSTEMS COMPUTATIONS TASKS (LIGHT ON WORK AREAS)	30	60
AUXILIARY POWER PLANT, ELECTRICAL AND ELECTRONIC COMPARTMENTS (LIGHT ON WORK AREAS)	5	10

[1]Continuous intensity control of the above lighting from full bright to 0.02% of full bright and "off" is required. The locations for these controls shall be approved by the acquiring activity.

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TABLE II. High Ambient Daylight Contrast Requirements

Types of Information to be Displayed	Required Contrast (C_L and C_I)	Contrast Compensations for other character heights and stroke widths
Numeric only	≥ 1.5 for h = 0.2 inch and $0.12h \leq SW \leq 0.2h$	Multiply Required Contrast by $0.2/h$ for $0.1 \leq h \leq 0.3$ and by $0.12h/SW$ for $0.01h \leq SW \leq 0.12h$
Alphanumeric	≥ 2.0 for h = 0.2 inch and $0.12h \leq SW \leq 0.2h$	
Graphic symbols and alphanumerics	≥ 3.0	
Video		
a. Worst case ambient condition	≥ 4.66, to make at least six $\sqrt{2}$ gray scale ratio shades visible (counting "off" as one)	
b. Otherwise	≥ 10.3, To make at least eight $\sqrt{2}$ gray scale ratio shades visible under other than worst case ambient conditions	

NOTES:

1. Character height criteria above assumes a viewing distance of less than 30 inches. No character height shall be less than 0.1 inch.
2. C_{UL} shall be ≤ 0.25 for all displays, and ≤ 0.1 for any display where unlighted elements could provide false information, rather than a meaningless array of dots or segments.
3. Definitions:
   - C_L = the ON/BACKGROUND contrast of a lighted (or activated) display image element
   - C_I = the ON/OFF contrast of a display image element
   - C_{UL} = the OFF/BACKGROUND contrast of an unlighted (or deactivated) display image element
   - h = character height
   - SW = character stroke width

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TABLE III. Mockup inspection.

Inspection	Paragraph	
	Requirement	Inspection Method
Lighting system unaided eye	3.4	4.8.1
Lighting system NVIS compatible	3.4	4.8.2
Design, location, actuation	3.4	4.8.3
Human engineering	3.11	4.8.4
Luminance uniformity	3.10.11	4.8.5
Crewstation reflections	3.10.12	4.8.6
Visual examination	---	4.8.7
Operation	---	4.8.8
Light leak inspection	3.10.10	4.8.15
Daylight legibility and readability	3.10.2	4.8.16

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TABLE IV. First article inspection.

Inspection	Paragraph	
	Requirement	Inspection Method
Visual examination	---	4.8.7
Operation	---	4.8.8
Environmental operating tests	3.10.4	4.8.9
Electromagnetic interference	3.10.5	4.8.10
Electromagnetic compatibility	3.10.6	4.8.11
Luminance and illuminance	3.10.7	4.8.12
Chromaticity	3.10.8	4.8.13
Spectral radiance	3.10.9	4.8.14
Light leak inspection	3.10.10	4.8.15
Daylight legibility and readability	3.10.2	4.8.16

TABLE V. Quality conformance inspection.

Inspection	Paragraph	
	Requirement	Inspection Method
Visual examination	---	4.8.7
Operation	---	4.8.8
Luminance and illuminance	3.10.7	4.8.12
Chromaticity	3.10.8	4.8.13
Spectral radiance	3.10.9	4.8.14
Light leak inspection	3.10.10	4.8.15
Daylight legibility and readability	3.10.2	4.8.16

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TABLE VI. Relative spectral response of Class A NVIS ($G_A(\lambda)$)

Wavelength(nm)	Relative Response	Wavelength (nm)	Relative Response
450	1.0000×10^{-4}	690	9.3790×10^{-1}
455	1.1250×10^{-4}	695	9.4480×10^{-1}
460	1.2500×10^{-4}	700	9.5170×10^{-1}
465	1.3750×10^{-4}	705	9.5860×10^{-1}
470	1.5000×10^{-4}	710	9.6550×10^{-1}
475	1.6172×10^{-4}	715	9.7304×10^{-1}
480	1.7500×10^{-4}	720	9.7930×10^{-1}
485	1.9375×10^{-4}	725	9.8020×10^{-1}
490	2.1250×10^{-4}	730	9.8280×10^{-1}
495	2.2266×10^{-4}	735	9.8838×10^{-1}
500	2.3750×10^{-4}	740	9.9310×10^{-1}
505	2.7656×10^{-4}	745	9.9719×10^{-1}
510	3.1250×10^{-4}	750	1.0000
515	3.4297×10^{-4}	755	1.0000
520	3.7500×10^{-4}	760	1.0000
525	4.1875×10^{-4}	765	1.0000
530	4.6250×10^{-4}	770	1.0000
535	5.0703×10^{-4}	775	9.9814×10^{-1}
540	5.500×10^{-4}	780	9.9660×10^{-1}
545	5.8359×10^{-4}	785	9.9543×10^{-1}
550	6.2500×10^{-4}	790	9.9450×10^{-1}
555	7.0000×10^{-4}	795	9.9380×10^{-1}
560	7.7500×10^{-4}	800	9.9310×10^{-1}
565	8.5000×10^{-4}	805	9.8620×10^{-1}
570	9.2500×10^{-4}	810	9.7930×10^{-1}
575	1.4525×10^{-3}	815	9.7283×10^{-1}
580	1.9800×10^{-3}	820	9.6550×10^{-1}
585	4.7175×10^{-3}	825	9.5515×10^{-1}
590	7.8000×10^{-3}	830	9.4480×10^{-1}
595	1.1400×10^{-2}	835	9.3402×10^{-1}
600	1.5000×10^{-2}	840	9.2410×10^{-1}
605	2.6263×10^{-2}	845	9.1720×10^{-1}
610	5.2000×10^{-2}	850	9.1030×10^{-1}
615	8.8388×10^{-2}	855	8.6334×10^{-1}
620	1.7500×10^{-1}	860	8.0000×10^{-1}
625	4.3288×10^{-1}	865	7.2848×10^{-1}
630	6.1380×10^{-1}	870	6.5520×10^{-1}
635	6.7756×10^{-1}	875	5.8016×10^{-1}
640	7.4480×10^{-1}	880	5.0340×10^{-1}
645	8.2458×10^{-1}	885	4.2523×10^{-1}
650	8.8970×10^{-1}	890	3.4480×10^{-1}
655	8.9654×10^{-1}	895	2.5704×10^{-1}
660	9.0340×10^{-1}	900	1.7500×10^{-1}
665	9.1051×10^{-1}	905	1.1009×10^{-1}
670	9.1720×10^{-1}	910	6.2100×10^{-2}
675	9.2241×10^{-1}	915	4.3125×10^{-2}
680	9.2760×10^{-1}	920	2.7600×10^{-2}
685	9.3254×10^{-1}	925	1.5525×10^{-2}
		930	6.9000×10^{-3}

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TABLE VII. Relative spectral response of Class B NVIS ($G_B(\lambda)$)

Wavelength(nm)	Relative Response	Wavelength (nm)	Relative Response
450	1.0000×10^{-5}	690	9.3790×10^{-1}
455	1.1250×10^{-5}	695	9.4480×10^{-1}
460	1.2500×10^{-5}	700	9.5170×10^{-1}
465	1.3750×10^{-5}	705	9.5860×10^{-1}
470	1.5000×10^{-5}	710	9.6550×10^{-1}
475	1.6172×10^{-5}	715	9.7304×10^{-1}
480	1.7500×10^{-5}	720	9.7930×10^{-1}
485	1.9375×10^{-5}	725	9.8020×10^{-1}
490	2.1250×10^{-5}	730	9.8280×10^{-1}
495	2.2266×10^{-5}	735	9.8838×10^{-1}
500	2.3750×10^{-5}	740	9.9310×10^{-1}
505	2.7656×10^{-5}	745	9.9719×10^{-1}
510	3.1250×10^{-5}	750	1.0000
515	3.4297×10^{-5}	755	1.0000
520	3.7500×10^{-5}	760	1.0000
525	4.1875×10^{-5}	765	1.0000
530	4.6250×10^{-5}	770	1.0000
535	5.0703×10^{-5}	775	9.9814×10^{-1}
540	5.5000×10^{-5}	780	9.9660×10^{-1}
545	5.8359×10^{-5}	785	9.9543×10^{-1}
550	6.2500×10^{-5}	790	9.9450×10^{-1}
555	7.0000×10^{-5}	795	9.9830×10^{-1}
560	7.7500×10^{-5}	800	9.9310×10^{-1}
565	8.5000×10^{-5}	805	9.8620×10^{-1}
570	9.2500×10^{-5}	810	9.7930×10^{-1}
575	9.7688×10^{-5}	815	9.7283×10^{-1}
580	1.1000×10^{-4}	820	9.6550×10^{-1}
585	1.2566×10^{-4}	825	9.5515×10^{-1}
590	1.8200×10^{-4}	830	9.4480×10^{-1}
595	2.6581×10^{-4}	835	9.3402×10^{-1}
600	5.2500×10^{-4}	840	9.2410×10^{-1}
605	1.0183×10^{-3}	845	9.1720×10^{-1}
610	2.0000×10^{-3}	850	9.1030×10^{-1}
615	3.4569×10^{-3}	855	8.6334×10^{-1}
620	6.2500×10^{-3}	860	8.0000×10^{-1}
625	9.0935×10^{-3}	865	7.2848×10^{-1}
630	1.8414×10^{-2}	870	6.5520×10^{-1}
635	4.6447×10^{-2}	875	5.8016×10^{-1}
640	7.4480×10^{-2}	880	5.0340×10^{-1}
645	2.0949×10^{-1}	885	4.2523×10^{-1}
650	4.0037×10^{-1}	890	3.4480×10^{-1}
655	6.7139×10^{-1}	895	2.5704×10^{-1}
660	9.0340×10^{-1}	900	1.7500×10^{-1}
665	9.1073×10^{-1}	905	1.1009×10^{-1}
670	9.1720×10^{-1}	910	6.2100×10^{-2}
675	9.2241×10^{-1}	915	4.3125×10^{-2}
680	9.2760×10^{-1}	920	2.7600×10^{-2}
685	9.3254×10^{-1}	925	1.5525×10^{-2}
		930	6.9000×10^{-3}

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TABLE VIII. Chromaticity requirements.

Lighting Component(s)	Paragraph	TYPE I										TYPE II									
		Class A					Class B					Class A					Class B				
		u'_1	v'_1	r	fL	NVIS Color	u'_1	v'_1	r	fl	NVIS Color	u'_1	v'_1	r	fL	NVIS Color	u'_1	v'_1	r	fL	NVIS Color
Primary	3.10.8.1	.088	.543	.037	0.1	Green A	Same as Class A					.088	.543	.037	0.1	Green A	Same as Class A				
Secondary	3.10.8.2	.088	.543	.037	0.1	Green A						.088	.543	.037	0.1	Green A					
Illuminated controls	3.10.8.3	.088	.543	.037	0.1	Green A						.088	.543	.037	0.1	Green A					
Compartment lighting	3.10.8.4	.088	.543	.037	0.1	Green A						.088	.543	.037	0.1	Green A					
Utility, work and inspection	3.10.8.5	.088	.543	.037	0.1	Green A						.088	.543	.037	0.1	Green A					
Caution and advisory signals	3.10.8.6	.088	.543	.037	0.1	Green A						.088	.543	.037	0.1	Green A					
Jump lights	3.10.8.7	.088	.543	.037	5.0	Green A						.088	.543	.037	5.0	Green A					
		.274	.622	.083	15.0	Yellow						.274	.622	.083	15.0	Yellow					
Special lighting components where increased display emphasis by highly saturated (monochromatic) colors is necessary, or adequate display light readability cannot be achieved with "GREEN A"	All of the above	.131	.623	.057	0.1	Green B						.131	.623	.057	0.1	Green B					
Warning signal	3.10.8.8.1	.274	.622	.083	15.0	Yellow	.274	.622	.083	15.0	Yellow	.274	.622	.083	15.0	Yellow	.274	.622	.083	15.0	Yellow
		NOT APPLICABLE					.450	.550	.060	15.0	Red	NOT APPLICABLE					.450	.550	.060	15.0	Red
Master Caution signal	3.10.8.8.2	.274	.622	.083	15.0	Yellow	Same as Class A					.274	.622	.083	15.0	Yellow	Same as Class A				

Where:

u'_1 and v'_1 = 1976 UCS chromaticity coordinates of the center point of the specified color area.

r = radius of the allowable circular area on the 1976 UCS chromaticity diagram for the specified color.

fL = footlamberts

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TABLE IX. NVIS radiance requirements.

Lighting component(s)		Paragraph	TYPE I						TYPE II					
			Class A			Class B			Class A			Class B		
			Not Less Than: (NR_A)	Not Greater Than: (NR_A)	fL	Not Less Than: (NR_B)	Not Greater Than: (NR_B)	fL	Not Less Than: (NR_A)	Not Greater Than: (NR_A)	fL	Not Less Than: (NR_B)	Not Greater Than: (NR_B)	fL
Primary		3.10.9.1	----	$1.7x10^{-10}$	0.1	1/ Same as Class A			----	$1.7x10^{-10}$	0.1	1/ Same as Class A		
Secondary		3.10.9.2	----	$1.7x10^{-10}$	0.1				----	$1.7x10^{-10}$	0.1			
Illuminated Controls		3.10.9.3	----	$1.7x10^{-10}$	0.1				----	$1.7x10^{-10}$	0.1			
Compartment		3.10.9.4	----	$1.7x10^{-10}$	0.1				----	$1.7x10^{-10}$	0.1			
Utility, work and inspection lights		3.10.9.5	----	$1.7x10^{-10}$	0.1				----	$1.7x10^{-10}$	0.1			
Caution and advisory lights		3.10.9.6	----	$1.7x10^{-10}$	0.1				----	$1.7x10^{-10}$	0.1			
Jump lights		3.10.9.7	$1.7x10^{-8}$	$5.0x10^{-8}$	5.0	$1.6x10^{-8}$	$4.7x10^{-8}$	5.0	----	$5.0x10^{-8}$	5.0	----	$4.7x10^{-8}$	5.0
Warning signal		3.10.9.8	$5.0x10^{-8}$	$1.5x10^{-7}$	15.0	$4.7x10^{-8}$	$1.4x10^{-7}$	15.0	----	$1.5x10^{-7}$	15.0	----	$1.4x10^{-7}$	15.0
Master Caution Signal		3.10.9.8	$5.0x10^{-8}$	$1.5x10^{-7}$	15.0	$4.7x10^{-8}$	$1.4x10^{-7}$	15.0	----	$1.5x10^{-7}$	15.0	----	$1.4x10^{-7}$	15.0
Emergency Exit Lighting		3.10.9.8	$5.0x10^{-8}$	$1.5x10^{-7}$	15.0	$4.7x10^{-8}$	$1.4x10^{-7}$	15.0	----	$1.5x10^{-7}$	15.0	----	$1.4x10^{-7}$	15.0
Electronic and electro-optical displays (Monochromatic)		3.10.9.9.1	----	$1.7x10^{-10}$	0.5	----	$1.6x10^{-10}$	0.5	----	$1.7x10^{-10}$	0.5	----	$1.6x10^{-10}$	0.5
Electronic and electro-optical displays (multi-color)	White	3.10.9.9.2	----	$2.3x10^{-9}$	0.5	----	$2.2x10^{-9}$	0.5	----	$2.3x10^{-9}$	0.5	----	$2.2x10^{-9}$	0.5
	Max		----	$1.2x10^{-8}$	0.5	----	$1.1x10^{-8}$	0.5	----	$1.2x10^{-8}$	0.5	----	$1.1x10^{-8}$	0.5
HUD systems		3.10.9.10	$1.7x10^{-9}$	$5.1x10^{-9}$	5.0	$1.6x10^{-9}$	$4.7x10^{-9}$	5.0	----	$1.7x10^{-9}$	5.0	----	$1.6x10^{-9}$	5.0

Where:

NR_A = NVIS radiance requirements for Class A equipment.

NR_B = NVIS radiance requirements for Class B equipment.

fL = footlamberts

NOTE:

1/ For these lighting components, Class B equipment shall meet all Class A requirements of this specification. The relative NVIS response data for Class A equipment, $G_A(\lambda)$ (Table VI), shall be substituted for $G_B(\lambda)$ to calculate NVIS radiance.

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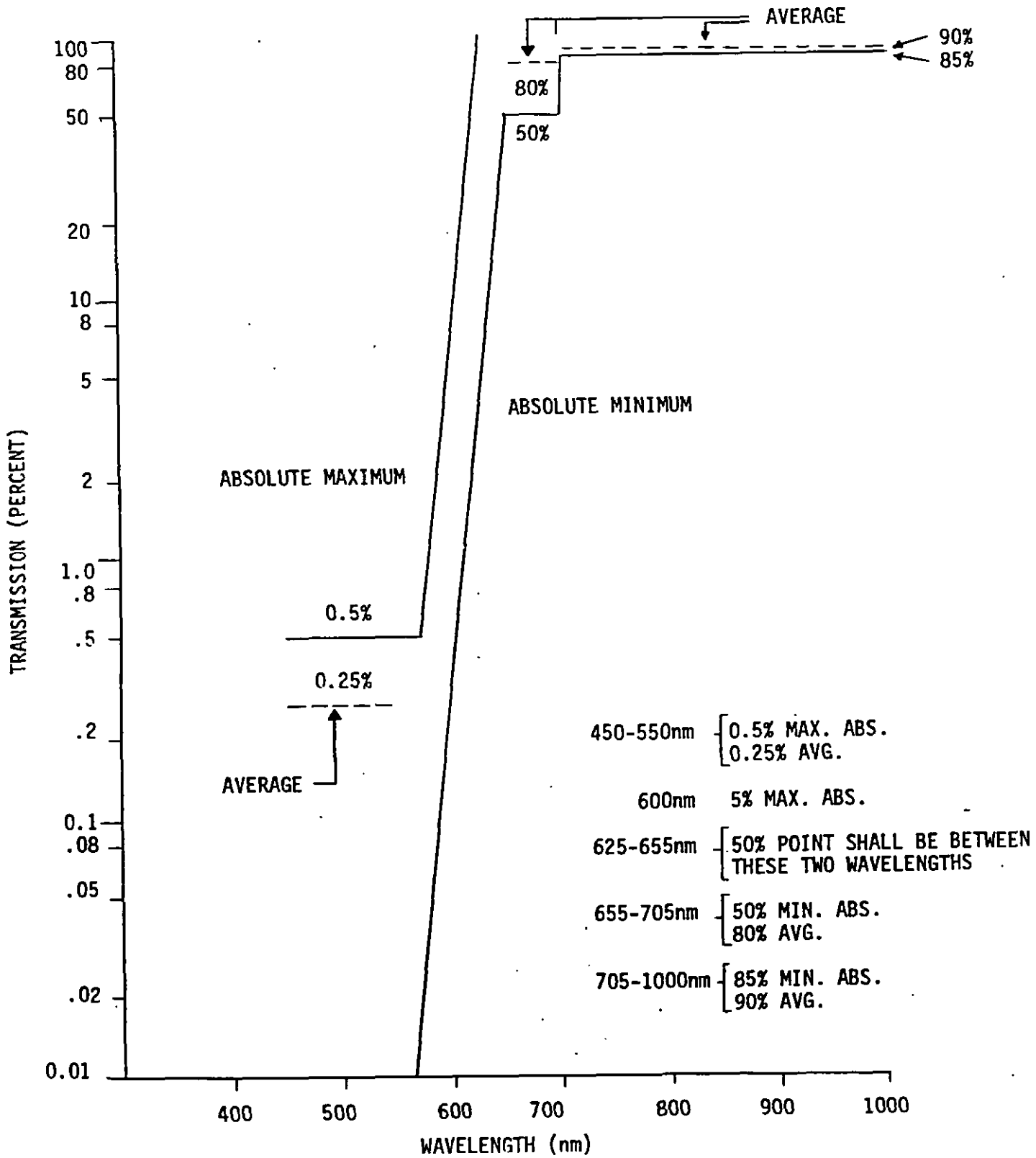


FIGURE 1. (Class A) 625 nm minus blue filter specification.

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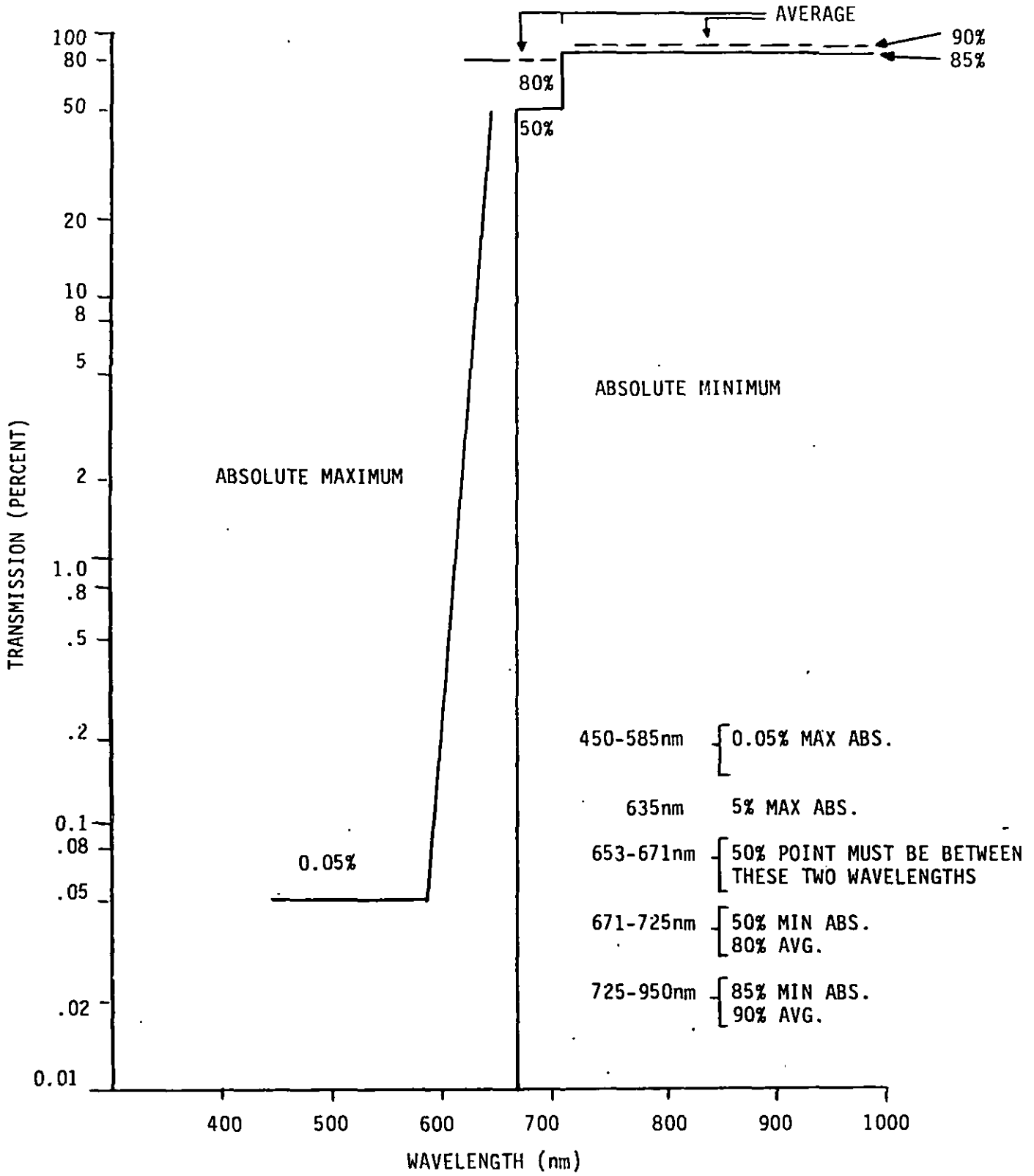
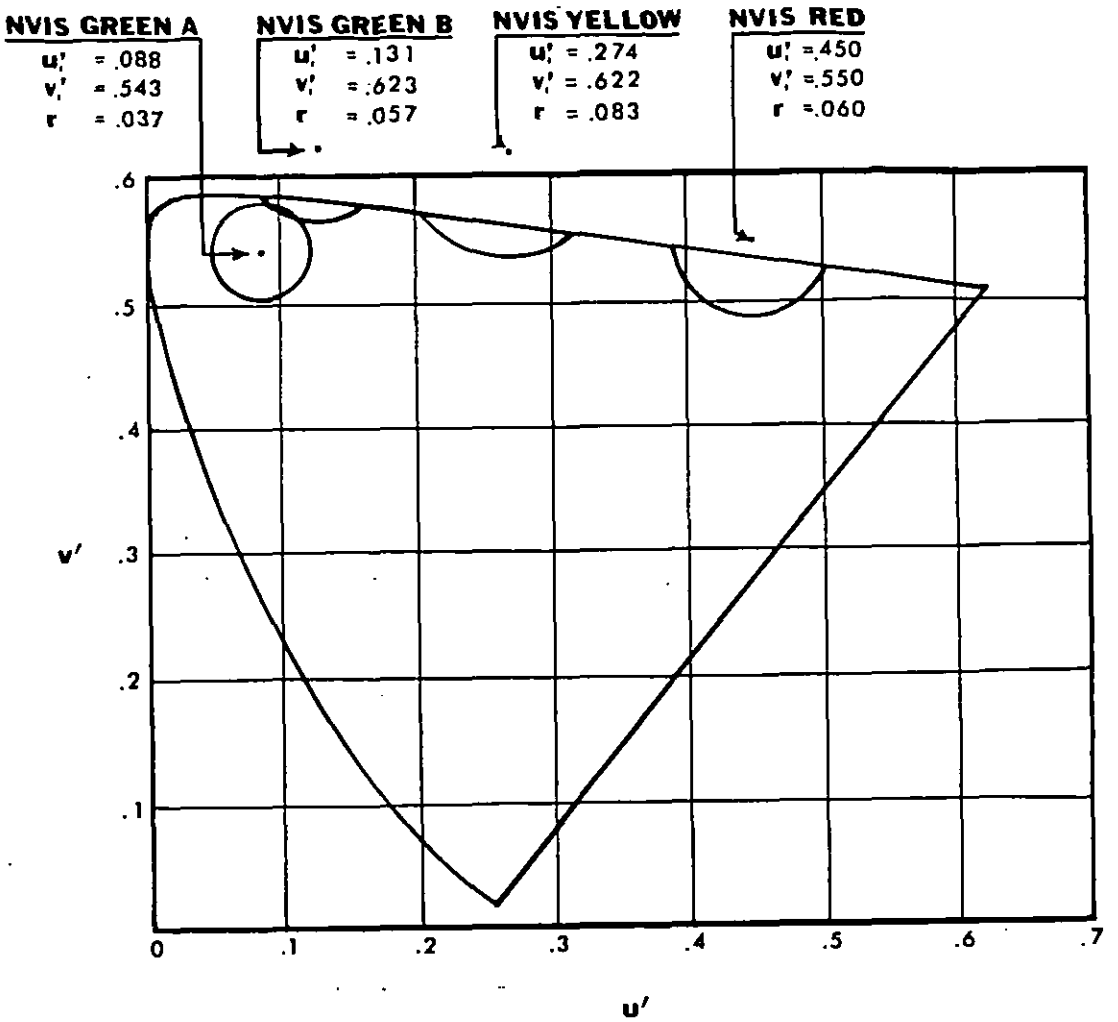


FIGURE 2. (Class B) 665 nm minus blue filter specification.

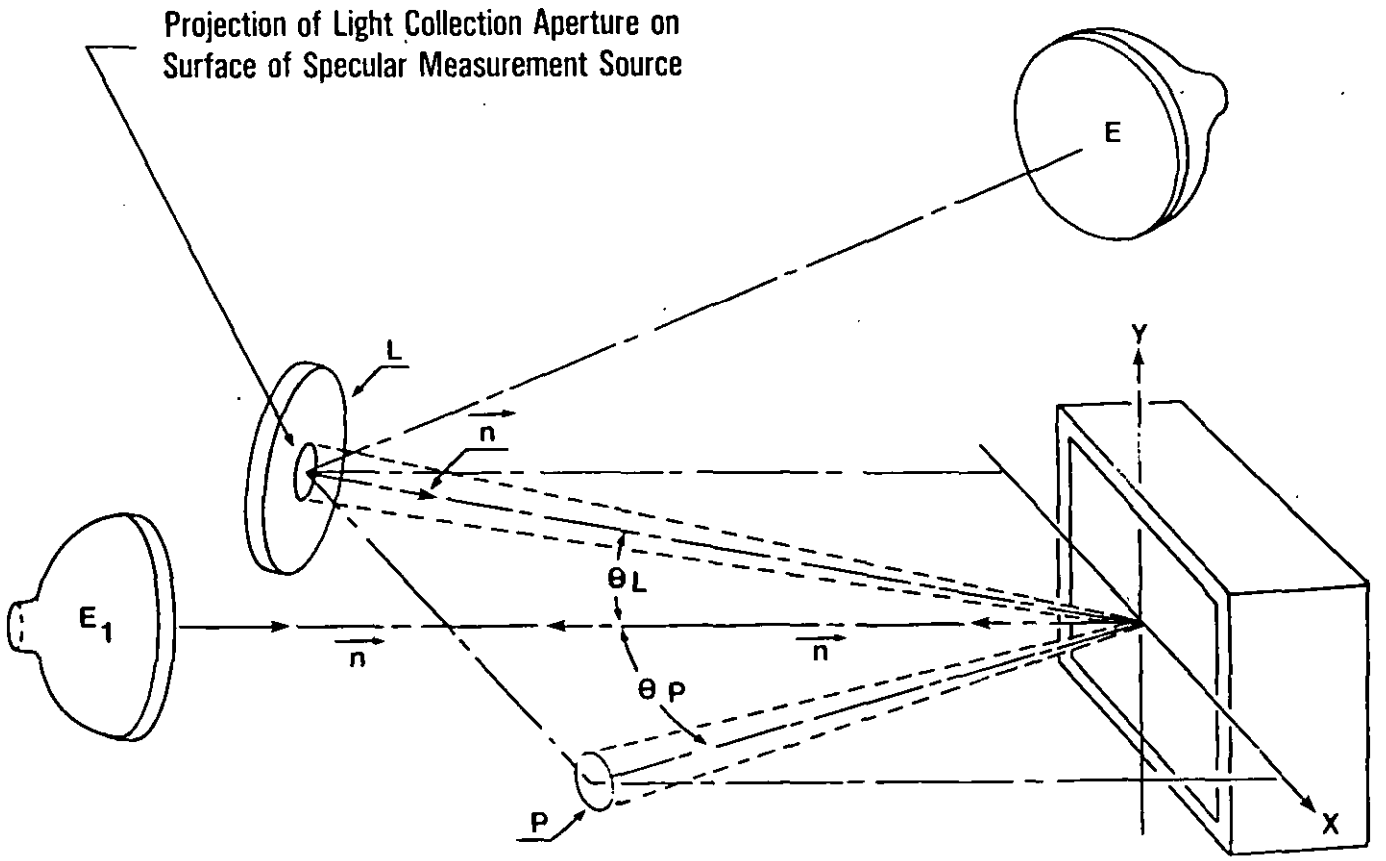
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CIE 1976 UCS DIAGRAM

FIGURE 3. NVIS lighting color limits (1976).

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E: Diffuse Measurement Illuminance Source

L: Specular Measurement Luminance Source: Uniform Luminance Source or Illumininated Diffuse Reflecting Surface

P: LUMINANCE Measuring Photometer Light Collection Aperture

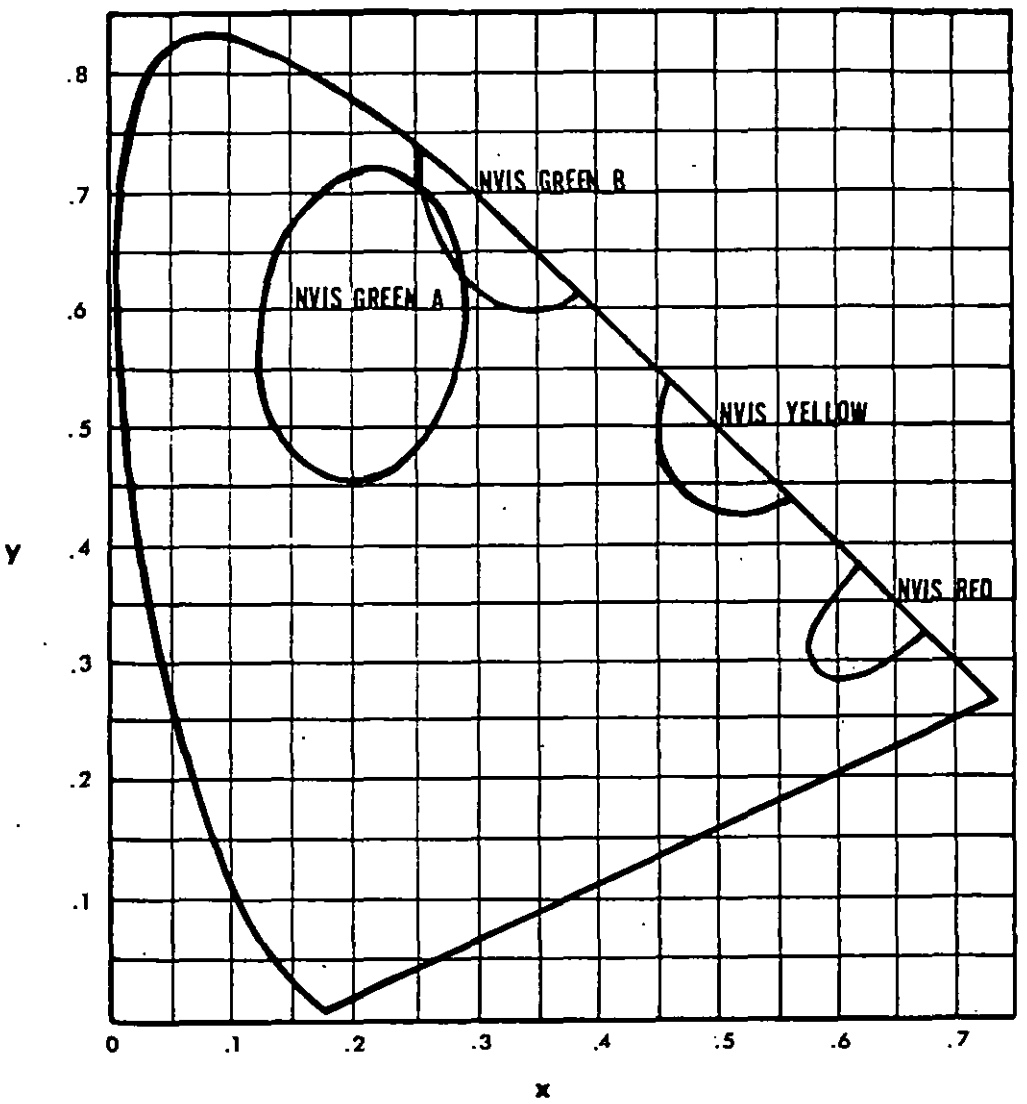
$\vec{n}$: Vector Normal to Surface

Combined Specular / Diffuse Measurement Configuration

FIGURE 4. Combined specular/diffuse measurement configuration.

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APPENDIX A



CIE 1931 CHROMATICITY DIAGRAM

Appendix A. NVIS LIGHTING COLOR LIMITS (1931)

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APPENDIX B

SPECTRAL RADIANCE, LUMINANCE, AND ILLUMINANCE MEASURING EQUIPMENT

B10. SCOPE

B10.1 Scope. This appendix details the requirements of the chromaticity, spectral radiance, luminance, and illuminance measurement equipment to be used when performing measurements in accordance with this specification. This Appendix is a mandatory part of this specification. The information contained herein is intended for compliance.

B20. APPLICABLE DOCUMENTS - This section is not applicable to this Appendix.

B30. SPECTRORADIOMETER

B30.1 Chromaticity and spectral radiance measurement equipment. Chromaticity and spectral radiance measurements shall be made using a spectroradiometer meeting the requirements herein. The following calibrations and checks shall be performed within the time period specified in order to assure that the spectroradiometer meets the requirements of this specification. Records of how the spectroradiometer calibration was performed, when performed and the standard lamp used shall be maintained by the contractor and shall be available for government inspection.

B30.2 Spectroradiometer sensitivity. The spectroradiometer, when assembled as a complete system, shall have sufficient sensitivity to permit measurement of radiance levels equal to or less than that listed in the table below at a half-power band width of 10 nm and a signal to root-mean-square noise ratio of 10:1.

Wavelength	Radiance Level
380 to 600 nm	1.0×10^{-10} W/cm^2 sr nm
600 to 900 nm	1.7×10^{-11} W/cm^2 sr nm
900 to 930 nm	1.0×10^{-10} W/cm^2 sr nm

B30.2.1 Spectroradiometer sensitivity calibration. Calibration of the spectroradiometer shall be performed within six months (or more frequently if required to insure that the spectroradiometer meets the requirements specified herein) prior to taking a measurement. This calibration shall be traceable to NBS standards. The calibrations shall be performed over the wavelength band and at intervals consistent with the measurements to be made. The calibration shall demonstrate that the spectroradiometer meets the sensitivity requirements of B30.2. A separate calibration must be performed for each spectroradiometer configuration used during tests. For example, a calibration must be performed for each set of optics used, or when filters are used in front of the spectroradiometer.

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B30.3 Wavelength accuracy and repeatability. The wavelength accuracy shall be within ± 1.0 nm. The wavelength accuracy is the difference between the wavelength actually being measured and the indicated wavelength. Wavelength repeatability shall be within ± 0.5 nm.

B30.3.1 Wavelength accuracy and repeatability verification. Wavelength accuracy and repeatability shall be verified within one month prior to taking a measurement using a source with known emission lines. As a minimum, the wavelength accuracy and repeatability shall be verified at one point in each 150 nm interval starting with 350 nm and ending with 950 nm. The wavelength accuracy and repeatability check shall be performed using either a scanning or non-scanning technique.

B30.3.1.1 Scanning technique. If the scanning technique is used, the spectroradiometer shall be utilized to measure the spectral radiance of the source by scanning from below the peak wavelength of the known emission line to be measured to above the peak wavelength in steps no greater than 0.1 nm. This process shall be repeated three times for each emission line that is used for the wavelength accuracy and repeatability test. The spectroradiometer shall be considered to have passed the wavelength accuracy test if, for each measurement, the wavelength of the measured peak is within 1 nm of the actual peak. The spectroradiometer shall be considered to have passed the wavelength repeatability test if, for each emission line tested, the wavelength of the three measured peaks are within 0.5 nm of each other.

B30.3.1.2 Non-scanning technique. If the non-scanning technique is used, the monochromator shall be positioned to obtain a peak reading for each emission line tested. The wavelength of the peak reading shall be recorded. Each emission line shall be measured three times. During this test the monochromator entrance and exit slit widths shall be no greater than 1 nm. The spectroradiometer shall be considered to have passed the wavelength accuracy test if, for each measurement, the wavelength of the measured peak is within 1 nm of the actual peak. The spectroradiometer shall be considered to have passed the wavelength repeatability test if, for each emission line tested, the wavelength of the three measured peaks are within 0.5 nm of each other.

B30.4 Current resolution: Where analog to digital (A to D) logic is used in the measurement of the current from the detector, the A to D conversion shall provide at least ± 2048 counts of resolution for each measurement scale or the resolution shall be equal to or better than ± 0.05% of each measurement scale.

B30.5 Zero drift. During any given spectroradiometric scan, the maximum zero drift shall be less than 0.2% of the full scale reading on the most sensitive scale, after the appropriate warm up period. A capability shall be provided to allow zero drift to be checked before any given spectroradiometric scan.

B30.6 Linearity. Within any given measurement scale, the linearity shall be ± 1% of the full scale value. The linearity between any two measurement scales shall be ± 2%.

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B30.6.1 Linearity verification. The linearity of the spectroradiometer shall be verified within 6 months prior to taking a measurement. A linearity check shall be performed on each detector used during the test procedures. The spectroradiometer operational parameters shall not be varied during the linearity test. The linearity check shall be performed at a specific wavelength (to be determined by the contractor) which shall not be varied during the linearity test. A light source which can be precisely, mechanically or optically varied in intensity shall be used for the linearity check. Acceptable methods that may be used to vary the intensity of the light source include the use of neutral density filters (with known transmission), precision apertures, superposition, or the inverse square law (provided the distance between the lamp and spectroradiometer can be precisely controlled using a photometric type bench). Dimming of the lamp through electronic means is unacceptable. The intensity of the lamp shall be adjusted to give a full scale reading on the lowest level of dynamic range of the spectroradiometer. Call the lamp output N and the reading on the spectroradiometer R. The intensity of the lamp shall be varied in accordance with the table below, and, in order to pass the linearity check, the output of the spectroradiometer, over its entire dynamic range (as applicable), shall be within the limits shown below.

Lamp Output	Spectroradiometer Output
0.1N	0.1R ± .01R
0.5N	0.5R ± .01R
5N	5.0R ± 0.2R
10N	10R ± 0.2R
50N	50R ± 2.0R
100N	100R ± 2.0R
500N	500R ± 20R
1000N	1000R ± 20R
5000N	5000R ± 200R
10000N	10000R ± 200R

B30.7 Signal conditioning. Controls shall be provided to permit the operator to improve or change the signal-to-noise ratio of a measurement.

B30.8 Stray light. Stray light within the spectroradiometer shall not adversely affect the accuracy of the spectroradiometer when tested in accordance with the procedures herein.

B30.8.1 Stray light verification. Stray light accuracy shall be verified within a 6 month period prior to taking a measurement. Stray light accuracy shall be verified by measuring the spectral radiance of an NBS traceable standard of spectral radiance which is filtered by a filter with known transmission that is NBS traceable. The measurement shall be made from 380 to 930 nm in 5 nm increments. The transmission of the filter shall be greater than 50% from 380 to 500 nm and less than 0.2% from 690 to 930 nm (see B60.1).

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For the spectroradiometer to pass the stray light test, the measured value of spectral radiance at each wavelength shall be within 5% of the value calculated by multiplying the output of the standard lamp by the transmission of the filter. The stray light shall be checked for each configuration of optics that is used during the testing.

B30.9 Spectroradiometer optics. If the spectroradiometer is used for luminance measurements, the optics shall be capable of allowing measurements of spot sizes down to .007 in with a full scale sensitivity of 1.0 fL.

B30.10 Spectroradiometer viewing system. The viewing system shall be capable of locating the spot to be measured with a maximum error of 5% of the diameter of the spot to be measured.

B30.10.1 Spectroradiometer viewing system verification. The accuracy of the viewing system shall be verified within a 6 month period prior to taking a test measurement by placing a black card with a hole in front of a light source in such a manner that an aperture in the spectroradiometer optics covers the hole when viewed through the viewing system. The card shall then be moved back and forth in one axis orthogonal to the axis of the spectroradiometer until a peak reading is obtained on the spectroradiometer. The distance (A) the card was moved from its original position to the peak position shall be recorded. The card shall be placed back in its original position and then moved back and forth in the axis orthogonal to the axis of the first movement and orthogonal to the axis of the spectroradiometer until a peak reading is obtained on the spectroradiometer. The distance (B) the card was moved from its original position to the peak position shall be recorded. The viewing system of the spectroradiometer shall be considered to be aligned accurately if both A and B are less than 5% of the diameter of the spot size at the card. The monochromator shall be set at a single wavelength for the entire test. For instruments for which the viewing optics and measuring optics are one in the same, this task is not required.

B30.11 Spectroradiometer accuracy. The spectroradiometer shall yield a spectral radiance within $\pm$ 5% of that of an NBS traceable standard of spectral radiance at each 5 nm wavelength throughout the range of 380 nm to 930 nm. When measuring an NBS traceable standard of color temperature or chromaticity, the spectroradiometer shall yield chromaticity coordinates u' and v' within $\pm$ 0.007 of their respective certificate values.

B30.11.1 Spectroradiometer accuracy verification. The accuracy shall be verified within a six month period prior to taking a test measurement. Verification shall be performed by measuring an NBS traceable spectral standard lamp other than the lamp used to calibrate the spectroradiometer and comparing the measured output to the certified output. The measured spectral radiance at each 5 nm wavelength over the 380 to 930 nm portion of the electromagnetic spectrum and the color coordinates calculated for the standard lamp shall not differ from the certified output by more than that specified in B30.11.

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B40. PHOTOMETER

B40.1 Luminance measurement equipment. Luminance measurements can be made using either a spectroradiometer meeting the requirements of B30 through B30.11.1 above or a photometer meeting the requirements herein. 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 in order to assure that the photometer meets the requirements of this specification. Records of calibrations and checks shall be maintained by the contractor and shall be available for government inspection.

B40.2 Photometer calibration. The photometer shall be calibrated using methods that are traceable to NBS standards.

B40.2.1 Photometer sensitivity. The full-scale sensitivity shall be 1.0 fL or less, with a spot size of no greater than 0.007 in.

B40.2.2 Photometer accuracy. The measured luminance of an NBS traceable luminance standard shall be within ±2% of the NBS certified luminance.

B40.2.3 Photometer sensitivity and accuracy verification. The full-scale sensitivity and accuracy of the photometer shall be verified using an NBS traceable standard of luminance set to a luminance value less than or equal to 1.0 fL and also equal to the known full-scale sensitivity value of one of the photometer ranges. Using a spot size no greater than 0.007 in. the photometer full scale sensitivity shall be within ± 2% of the NBS traceable standard of luminance value.

B40.3 Readout resolution. The unit shall have a digital readout with a resolution better than or equal to 0.1% of full scale.

B40.4 Photometer optics. The optics shall be capable of allowing measurements of spot sizes down to 0.007 in. while meeting the sensitivity requirements of B40.2.1. The optics shall be capable of focusing to no less than 4.0 in.

B40.5 Photometer viewing system. The viewing system must be capable of locating the spot to be measured with a maximum error of 0.002 in.

B40.5.1 Photometer viewing system verification. A black card, with a hole in the center, shall be placed in front of a light source in such a manner that the smallest aperture of the photometer optics covers the hole when viewed through the viewing system. The card shall be moved back and forth in one axis orthogonal to the axis of the photometer until a peak reading is obtained on the photometer. The distance (A) the card was moved from its original position to the peak position shall be recorded. The card shall be placed back in its original position and then moved back and forth in the axis orthogonal to the axis of the first movement and orthogonal to the axis of the photometer until a peak reading is obtained on the photometer.

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The distance (B) the card was moved from its original position to the peak position shall be recorded. The viewing system of the photometer shall be considered to be aligned accurately if both A and B are less than or equal to 0.002 in. For instruments in which the viewing aperture and measuring aperture are one in the same, this test is not required.

B40.6 Photometer polarization error. The polarization error shall be no greater than 1%.

B40.6.1 Photometer polarization error verification. The polarization error shall be checked by placing a linear polarizer in the optical path between the standard lamp and the photometer and then measuring the luminance. The polarizer shall be rotated 45° and another measurement shall be made. The polarizer shall be rotated another 45° and another measurement shall be made. The photometer shall be considered as having passed the polarization error test if the difference between the three measurements is lower than or equal to the percent error specified in B40.6. Throughout the test the alignment of the standard lamp shall not be changed. The transmission of the linear polarizer shall be greater than or equal to 20%, and the transmission of two pieces of the polarizer material, when oriented so that the direction of polarization of the two pieces are at right angles, shall be less than or equal to 0.1%.

B40.7 Colorimetry. When colorimetry capability is required, the photometer shall be calibrated to measure the NVIS color for the application (i.e. NVIS Green A, NVIS Green B, NVIS Yellow or NVIS Red). The calibration shall be traceable to NBS standards.

B50. REFLECTANCE STANDARD

B50.1 Reflectance standard. The reflectance standard shall have a lambertian reflecting surface with reflectivity greater than 90% from 380 nm to 930 nm. The length and width of the reflecting surface shall be at least 2 inches by 2 inches.

B50.1.1 Reflectance standard verification. The reflectance of the reflectance standard shall be measured within a 6 month period prior to each test. The measured reflectance shall be used as a calibration figure whenever the reflectance standard is used. The measurement of the reflectance shall be traceable to NBS standards. The reflectance standard shall be calibrated using the same orientation as that used in 4.8.13 and 4.8.14.

B60. NOTES

B60. Filter. A 0.12 in. thick piece of Schott BG-23 or equivalent should meet the transmission requirements of B30.8.1.

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APPENDIX C

SAMPLE CALCULATIONS

C10. SCOPE

C10.1 Scope. This Appendix contains sample calculations used to determine compatibility with Type I Class A NVIS. This Appendix is not a mandatory part of this specification. The information contained herein is intended for guidance only. The following sample calculations are based upon data obtained during the measurement of one particular lighting component, an advisory signal to be used with Type I Class A equipment. The chromaticity coordinates and NVIS radiance values derived from the following sample calculation apply to this particular device only.

C20. APPLICABLE DOCUMENTS - This section is not applicable to this Appendix.

C30. NVIS RADIANCE CALCULATIONS. As specified in Table IX, the required luminance level for NVIS radiance, L_r, for advisory signals is 0.1 footlamberts (fL). As specified in 4.8.14.1 the luminance of the lighting component at rated drive conditions, L_m , was measured by the spectroradiometer to be 1.7839 fL. From this information a scaling factor can be generated using Formula 13:

$$S = \frac{L_r}{L_m} = \frac{0.1 fL}{1.7839 fL} = 5.605695 \times 10^{-2} \qquad \text{(Formula 13)}$$

Where:

S = scaling factor
L_r = required luminance level for NVIS radiance
L_m = luminance measured by the spectroradiometer

Figure C-1 is a plot of the spectral output of the signal when it is energized to produce 1.7839 fL. NVIS radiance is then calculated using Formula 14a:

$$\text{NVIS radiance} = G(\lambda)_{max} \int_{450}^{930} G_A(\lambda)\, S\, N(\lambda)\, d\lambda \quad NR_A \qquad \text{(Formula 14a)}$$

Where:

$G(\lambda)_{max}$ = 1 mA/W
$G_A(\lambda)$ = relative NVIS response (see Table VI)
S = 5.605695×10^{-2}
$N(\lambda)$ = spectral radiance of lighting component (W/cm^2 sr nm) (see Figure C-1)
$d\lambda$ = 5 nm

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NOTE: In Figure C-1, the units of radiance are ($\mu W/cm^2$ sr nm). To obtain the correct units of radiance for Formula 14a, the values in Figure C-1 must be multiplied by 1.0×10^{-6}.

Performing the above calculation yields an NVIS radiance for this component of 4.73613×10^{-11} NR_A. This component conforms to the requirement of Table IX to be not greater than 1.7×10^{-10} NR_A for Class A equipment.

C40. CHROMATICITY CALCULATIONS. As specified in Table VIII chromaticity measurements shall be conducted on advisory signals when the component is energized to produce 0.1 fL. Figure C-2 is a plot of the spectral output of the signal when it is energized to produce 0.1 fL. From 4.8.13, Formulas 5, 6 and 7 are used to calculate the following tristimulus values for this signal.

$X = 1.90229 \times 10^{-7}$
$Y = 5.12926 \times 10^{-7}$
$Z = 8.47261 \times 10^{-9}$

These tristimulus values are then used to calculate the 1931 C.I.E. chromaticity coordinates using Formulas 8 and 9.

$x = 0.241443791$
$y = 0.651019551$

These 1931 C.I.E. Chromaticity coordinates are then used to calculate the 1976 UCS chromaticity coordinates using Formulas 10 and 11.

$u' = 0.0935$
$v' = 0.5672$

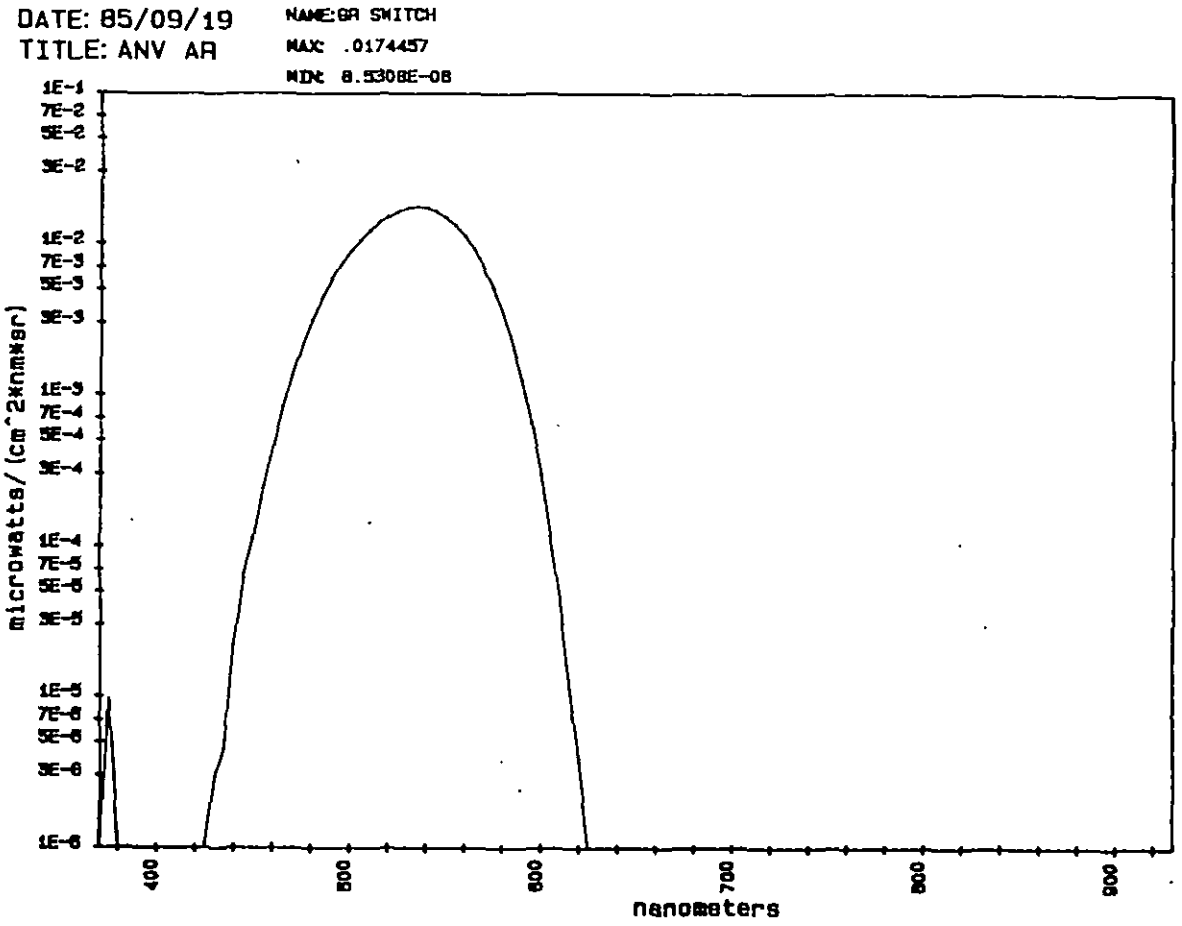
When substituted into Formula 1 of 3.10.8., the 1976 UCS chromaticity coordinates indicate that this particular lighting component meets the requirements of Table VIII for "NVIS GREEN A" Type I Class A compatible equipment.

$$(u' - u'_1)^2 + (v' - v'_1)^2 \leq (r)^2 \qquad \text{(Formula 2)}$$

Where:

$u'_1 = .088$ (see 3.10.8.6)
$v'_1 = .543$ (see 3.10.8.6)
$r = .037$ (see 3.10.8.6)

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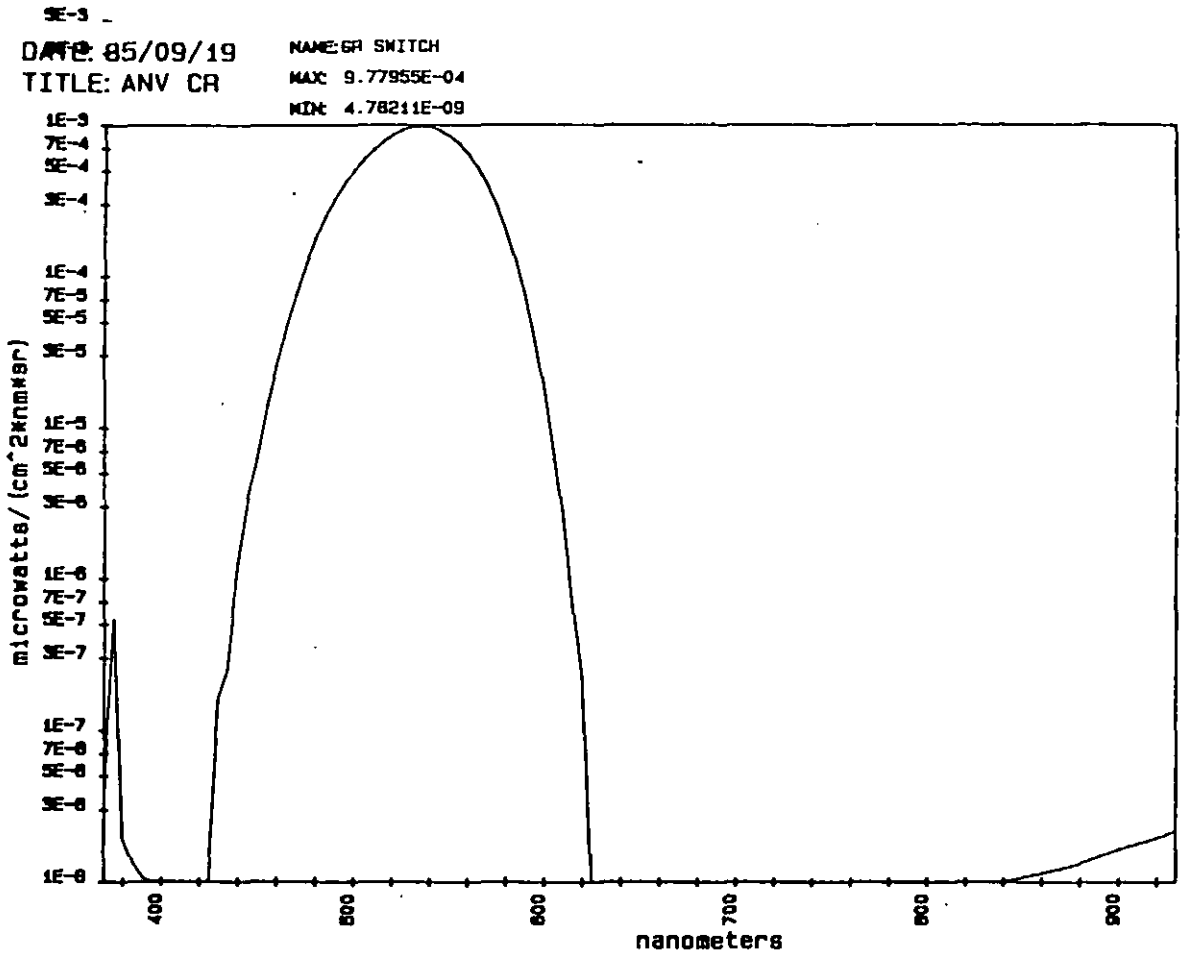


Device name: GR SWITCH
Units: Wavelength (nm) Radiance ($\mu W/cm^2$ nm sr)
Calibration date: 85/08/29 Calibration Standard: HL588.RAD

370	7.3754E-07	510	1.2119E-02	650	8.5490E-08	790	1.3246E-07
375	9.6851E-06	515	1.3788E-02	655	8.5535E-08	795	1.3643E-07
380	3.3755E-07	520	1.5080E-02	660	8.5803E-08	800	1.4055E-07
385	2.3725E-07	525	1.6328E-02	665	8.5849E-08	805	1.4477E-07
390	1.8954E-07	530	1.7123E-02	670	8.6139E-08	810	1.4937E-07
395	1.6962E-07	535	1.7446E-02	675	8.6493E-08	815	1.5412E-07
400	1.5954E-07	540	1.7171E-02	680	8.7098E-08	820	1.5889E-07
405	1.5383E-07	545	1.6200E-02	685	8.7658E-08	825	1.6421E-07
410	1.4772E-07	550	1.4850E-02	690	8.8377E-08	830	1.6918E-07
415	1.4203E-07	555	1.3188E-02	695	8.9149E-08	835	1.7419E-07
420	1.3855E-07	560	1.1186E-02	700	9.0179E-08	840	1.7931E-07
425	1.3974E-07	565	9.1515E-03	705	9.1054E-08	845	1.8455E-07
430	2.9100E-06	570	7.0494E-03	710	9.2189E-08	850	1.9024E-07
435	4.6091E-06	575	5.1191E-03	715	9.3707E-08	855	1.9635E-07
440	2.2454E-05	580	3.4680E-03	720	9.5104E-08	860	2.0274E-07
445	6.0578E-05	585	2.1926E-03	725	9.6411E-08	865	2.0992E-07
450	1.1215E-04	590	1.2660E-03	730	9.7374E-08	870	2.1766E-07
455	2.4485E-04	595	6.6028E-04	735	9.7622E-08	875	2.2633E-07
460	4.5484E-04	600	3.0882E-04	740	9.5771E-08	880	2.3628E-07
465	8.2161E-04	605	1.1893E-04	745	9.4317E-08	885	2.4891E-07
470	1.3433E-03	610	4.3606E-05	750	9.6128E-08	890	2.6236E-07
475	2.1281E-03	615	1.2054E-05	755	1.0155E-07	895	2.7604E-07
480	3.1192E-03	620	3.9837E-06	760	1.0799E-07	900	2.8953E-07
485	4.3367E-03	625	8.6170E-08	765	1.1334E-07	905	3.8283E-07
490	5.7409E-03	630	8.5718E-08	770	1.1777E-07	910	3.1601E-07
495	7.2920E-03	635	8.5459E-08	775	1.2149E-07	915	3.2946E-07
500	8.8926E-03	640	8.5308E-08	780	1.2519E-07	920	3.4522E-07
505	1.0478E-03	645	8.5455E-08	785	1.2876E-07	925	3.6457E-07
						930	3.8781E-07

FIGURE C-1. Spectral output of example signal at rated drive conditions (1.7839fL).

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Device name: GR SWITCH
Units: Wavelength (nm) Radiance ($\mu W/cm^2$ nm sr)
Calibration date: 85/08/29 Calibration Standard: HL588.RAD

370	4.1344E-08	515	7.7290E-04	660	4.8099E-04	805	8.1152E-09
375	5.4292E-07	520	8.4535E-04	665	4.8124E-09	810	8.3734E-09
380	1.8922E-08	525	9.1528E-04	670	4.8287E-09	815	8.6396E-09
385	1.3299E-08	530	9.5984E-04	675	4.8485E-09	820	8.9070E-09
390	1.0625E-08	535	9.7796E-04	680	4.8824E-09	825	9.2053E-09
395	9.5086E-09	540	9.6253E-04	685	4.9138E-09	830	9.4840E-09
400	8.9434E-09	545	9.0811E-04	690	4.9541E-09	835	9.7644E-09
405	8.6230E-09	550	8.3245E-04	695	4.9974E-09	840	1.0051E-08
410	8.2810E-09	555	7.3926E-04	700	5.0524E-09	845	1.0345E-08
415	7.9616E-09	560	6.2707E-04	705	5.1042E-09	850	1.0664E-08
420	7.7668E-09	565	5.1300E-04	710	5.1678E-09	855	1.1007E-08
425	7.8335E-09	570	3.9517E-04	715	5.2529E-09	860	1.1365E-08
430	1.6313E-07	575	2.8696E-04	720	5.3312E-09	865	1.1767E-08
435	2.5837E-07	580	1.9440E-04	725	5.4045E-09	870	1.2201E-08
440	1.2587E-06	585	1.2291E-04	730	5.4585E-09	875	1.2688E-08
445	3.3958E-06	590	7.0971E-05	735	5.4724E-09	880	1.3245E-08
450	6.2867E-06	595	3.7013E-05	740	5.3686E-09	885	1.3953E-08
455	1.3726E-05	600	1.7312E-05	745	5.2871E-09	890	1.4707E-08
460	2.5497E-09	605	6.6671E-06	750	5.3887E-09	895	1.5474E-08
465	4.6057E-05	610	2.4444E-06	755	5.6928E-09	900	1.6230E-08
470	7.5304E-05	615	6.7572E-07	760	6.0537E-09	905	1.6976E-08
475	1.1930E-04	620	2.2331E-07	765	6.3536E-09	910	1.7715E-08
480	1.7485E-04	625	4.8304E-09	770	6.6017E-09	915	1.8468E-08
485	2.4310E-04	630	4.8051E-09	775	6.8102E-09	920	1.9352E-08
490	3.2182E-04	635	4.7906E-09	780	7.0176E-09	925	2.0437E-08
495	4.0877E-04	640	4.7821E-09	785	7.2177E-09	930	2.1740E-08
500	4.9849E-04	645	4.7903E-09	790	7.4253E-09		
505	5.8734E-04	650	4.7923E-09	795	7.6479E-09		
510	6.7938E-04	655	4.7948E-09	800	7.8787E-09		

FIGURE C-2. Spectral output of example signal at 0.1fL.

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