



400 Commonwealth Drive, Warrendale, PA 15096-0001

AEROSPACE STANDARD

SAE AS7788

Issued 1999-07

Panels, Information, Integrally Illuminated

FSC 6220

NOTICE

This document has been taken directly from U.S. Military Specification MIL-P-7788F, Amendment 1 and contains only minor editorial and format changes required to bring it into conformance with the publishing requirements of SAE technical standards. The initial release of this document is intended to replace MIL-P-7788F, Amendment 1. Any part numbers established by the original specification remain unchanged.

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Under Department of Defense policies and procedures, any qualification requirements and associated qualified products lists are mandatory for DOD contracts. Any requirement relating to qualified products lists (QPL's) has not been adopted by SAE and is not part of this SAE technical document.

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1. SCOPE:

1.1 Scope:

This specification covers the general requirements for integrally illuminated information panels.

1.2 Classification:

The panels shall be furnished in the following types and classes as specified (see 6.2).

1.2.1 Classes:

Class 1-R. Panels having the background of the front face of the panel finished with black and the integral illumination of Instrument and Panel Lighting (IPL) - Red.

Class 1-W. Panels having the background of the front face of the panel finished with black and the integral illumination of Instrument and Panel Lighting (IPL) - White.

Class 1-BW. Panels having the background of the front face of the panel finished with black and the integral illumination of (USAF) Blue-Filtered White.

Class 1-NVIS Green A. Panels having the background of the front face of the panel finished with black and the integral illumination meeting the Class A NVIS compatible lighting requirements of MIL-L-85762 is NVIS Green A.

Class 2-R. Panels having the background of the front face of the panel finished with gray and the integral illumination of Instrument and Panel Lighting (IPL) - Red.

Class 2-W. Panels having the background of the front face of the panel finished with gray and the integral illumination of Instrument and Panel Lighting (IPL) - White.

Class 2-BW. Panels having the background of the front face of the panel finished with gray and the integral illumination of (USAF) Blue-Filtered White.

1.2.2 Types:

Type III - One piece plastic panels. Panels consisting of one sheet of plastic utilizing MS25237 lamps in MS25010 light assemblies for illumination.

NOTE: Type III panels shall be inactive for new design. Qualification for Type III panels shall be determined by qualification for Types IV or V. Type III panels may be updated to Types IV or V by the use of adapter plug MS90335-9 (see 6.8).

Type IV - One piece integrally wired incandescent panels. Panels consisting of one sheet of plastic using MS24367, MS90451, or MS90452 lamps and wiring embedded within the panel.

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1.2.2 (Continued):

Type V - Printed circuit board panels. Panels consisting of one sheet of plastic with MS24367, MS24515, MS90451, or MS90452 lamps soldered to a removeable printed circuit board that is recessed so that the circuit board is flush with the back of the plastic panel. The filter element is an integral part of the plastic panel whereas the lamp is an integral part of the circuit board. When specified by the procuring activity, an alternate approach may use these lamps in a based configuration and with T1 or T1 3/4 front relampable light assemblies (see 3.4.3.4.1).

Type VI - Electroluminescent panels. Panels consisting of one sheet of plastic with encapsulated electroluminescent lamps or a combination of electroluminescent lamps.

Type VII - Light emitting diode (LED) panels. Panels consisting of LEDs soldered to a removable printed circuit board recessed so that the circuit board is flush with the back of the plastic panel.

APPLICABLE DOCUMENTS:

2.1 Government Documents:

- 2.1.1 Specifications, standards, and handbooks: The following specifications, standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are 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).

SPECIFICATIONS

FEDERAL

- C-F-206 - Felt, Sheet, Cloth, Felt, Wood, Pressed
- L-P-380 - Plastic Molding Material, Methacrylate
- P-C-444 - Cleaning Compound, Solvent Soluble, Grease Emulsifying
- TT-T-266 - Thinner, Dope and Lacquer (Cellulose-Nitrate)

MILITARY

- MIL-P-116 - Preservation, Methods of
- DOD-D-1000 - Drawings, Engineering and Associated Lists
- MIL-P-5425 - Plastic, Sheet, Acrylic, Heat Resistant
- MIL-L-6081 - Lubricating Oil, Jet Engine
- MIL-L-6363 - Lamps, Incandescent, Aircraft Service General Specification for
- MIL-C-6781 - Control Panel, Aircraft Equipment, Rack or Console Mounted
- MIL-P-13949 - Plastic Sheet, Laminated, Metal Clad (For Printed Wiring Boards), General Specification for
- MIL-M-18012 - Markings for Aircrew Station Displays, Design and Configuration of
- MIL-T-18303 - Test Procedure; Preproduction, Acceptance, and Life for Aircraft Electronic Equipment, Format For

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2.1.1 (Continued):

MIL-S-19500	- Semiconductor Device, General Specification for
MIL-S-22885	- Switch, Push Button, Illuminated, General Specification for
MIL-C-25050	- Colors, Aeronautical Lights and Lighting Equipment, General Requirements for
MIL-L-25467	- Lighting, Integral, Red, Aircraft Instrument, General Specification for
MIL-S-38039	- System, Illuminated, Warning, Caution, and Advisory, General Specification for
MIL-I-46058	- Insulating Compound, Electrical (For Coating Printed Circuit Assemblies)
MIL-A-49425	- Aviator's Night Vision Imaging System AN/AVS-6(v)1, AN/AVS-6(v)2
MIL-H-83282	- Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Aircraft
MIL-L-85762	- Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible
MIL-D-87157	- Displays, Diode, Light Emitting, Solid State, General Specification for

STANDARDS

FEDERAL

FED-STD-376	- Preferred Metric Units for General Use by the Federal Government
FED-STD-595	- Color

MILITARY

MIL-STD-105	- Sampling Procedures and Tables for Inspection by Attributes
MIL-STD-129	- Marking for Shipment and Storage
MIL-STD-130	- Identification Marking of U.S. Military Property
MIL-STD-202	- Test Methods for Electronic and Electrical Component Parts
MIL-STD-411	- Aircrew Station Alerting Systems
MIL-STD-454	- Standard General Requirements for Electronic Equipment
MIL-STD-461	- Electromagnetic Emission and Susceptible, Requirements for the Control of Electromagnetic Interference
MIL-STD-462	- Electromagnetic Interference Characteristics, Measurement of
MIL-STD-810	- Environmental Test Methods and Engineering Guidelines
MIL-STD-2000	- Standard Requirements for Soldered Electrical and Electronic Assemblies
MIL-STD-2073-1	- DOD Materiel Procedures for Development and Application of Packaging Requirements
MS3338	- Lamp, Incandescent, T-1 Bulb (Based)
MS3498	- Grommets with screw, Integrally Illuminated Information Panel Mounting
MS24367	- Lamp, Incandescent - Miniature, Integral Lighting
MS24515	- Lamp - Sub-Miniature
MS25010	- Light, Panel - Plastic Plate Lighting
MS25237	- Lamp, Incandescent, Single Contact, Midget Flanged Base (T-1 3/4 Bulb)
MS90335	- Connector, Receptacles, Plug Adapter, Electroluminescent, Embedded, Printed Circuit Board Lamp Lighting Panels

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2.1.1 (Continued):

- MS90451 - Lamp, Incandescent, T-1 Bulb, Short, Integral Lighting
MS90452 - Lamp, Incandescent, T-3/4 Bulb, Integral Lighting

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Ave. Bldg. #4, Philadelphia, PA 19111-5094.)

2.1.2 Other Government documents, drawings, and publications: The following other Government documents, drawings, and publications form a part of this document to the extent specified herein. Unless otherwise specified, the issues are those cited in the solicitation.

- SD-6 - Provisions Governing Qualification (Qualified Products List)

(Unless otherwise indicated, copies of federal and military specifications, standards, and handbooks are available from the Standardization Document Order Desk, 700 Robbins Ave. Bldg. #4, Philadelphia, PA 19111-5094.)

2.2 Non-Government publications:

The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of the documents which are DOD adopted are those listed in the issue of the DODISS cited in the solicitation. Unless otherwise specified, the issues of documents not listed in the DODISS are the issues of the documents cited in the solicitation (see 6.2).

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

- D523 Method of test for Specular Gloss of Paint Finishes
D1729 Standard Practice for Visual Evaluation of Color Differences of Opaque Materials
E275 Standard Practice for Describing and Measuring Performance of Ultraviolet, Visible, and Near Infrared Spectrophotometers
E925 Standard Practice for the Periodic Calibration of Narrow Band-Pass Spectrophotometers
G26 Standard Practice for Operating Light Exposure Apparatus (Xenon-Arc Type) With and Without Water for Exposure of Nonmetallic Materials
STP 15D ASTM Manual on Presentation of Data and Control Chart Analysis

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pennsylvania 19103-1187.)

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2.2 (Continued):

ELECTRONIC INDUSTRIES ASSOCIATION

EIA 557 Statistical Process Control Systems

(Application for copies should be addressed to the Electronic Industries Association, 2001 Eye St., NW., Washington, D.C. 20006)

2.3 Order of precedence:

In the event of a conflict between the text of this document and the references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. REQUIREMENTS:

3.1 Qualification:

Panels furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time of award of contract (see 4.2 and 6.3). These products shall be representative of a process which has been qualified through tests on a special panel (see Figure 1). The tests described under Section 4 shall apply to this panel. Production panels are a variety of shapes and sizes and will not resemble the qualification panel (Figure 1). Requalification shall consist of the same tests described in Section 4 as for qualification.

3.1.1 Retention of qualification: Retention of qualification consists of periodic verification of compliance of the product with the requirements of this specification. The manufacturer shall provide a letter of certification of compliance or DD Form 1718 to the activity responsible for the Qualified Products List at intervals of not more than two years. The letter shall attest that the qualified panels are still available from the listed plant and can be produced in the same plant under the same conditions as when qualified. Any changes in plant location, parts, materials, design or processes for manufacture of the panels shall be reported as required by SD-6, Provisions Governing Qualification. The manufacturer shall also submit an Illumination Test Facility Certification Report, certified by QAR. The Government reserves the right to require additional tests and/or a facilities inspection to determine compliance with this specification.

3.1.2 Qualification by similarity: Qualification may also be granted on the basis of similarity provided qualification is achieved within the past two years for at least a Type IV, a Type V, and a minimum of two appropriate dissimilar classes. Qualification may also be granted for Type VII panels on the basis of similarity provided qualification is achieved within the past two years for other Type VII panels using the same LED lamps and internal circuit design. However, qualification shall not be granted for Class 1-NVIS Green A on the basis of prior qualification for other types or classes. Neither shall qualification be granted for Type VI panels utilizing different phosphors nor for Type VII panels using different LED lamps and different internal circuit design on the basis of prior qualification for Types IV or V or for other classes.

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3.1.2 (Continued):

Qualification by similarity for all classes in Types IV, V, VI, and VII:
(The same manufacturing process must be used for all.)

Type IV: Classes 1-W, 2-R, 1-NVIS Green A

Type V: Classes 1-BW, 1-NVIS Green A

Type VI: Classes 1-W, 2-R, 1-BW, 1-NVIS Green A

Type VII: Classes 1-W, 2-R, 1-BW, 1-NVIS Green A

Typically, any combination within a particular Type that has all illumination colors represented (i.e., red, white, blue-white, and NVIS Green A) as well as both background colors (i.e., black and gray) will qualify by similarity for all Classes within that Type. (E.g., Successful qualification of Type V Classes 1-W, 2-R, 1-BW, 1-NVIS Green A will result in qualification by similarity for the remaining Types and Classes in Type V.) As stated above, NVIS Green A is never qualified by similarity. The only qualification by similarity across Types for illuminated color (except NVIS Green A) occurs for Types IV and V since both use incandescent lamps for illumination. Other qualification by similarity options can be arranged; contact the qualifying activity for approval.

3.2 First article:

In the event there are less than two vendors for a specific type and class of panel listed on the current QPL at the time set for the opening of bids, the procuring activity shall require first article inspection equivalent to Qualification inspection of section 4 of this specification. The first article test procedures shall be approved by the qualifying activity prior to beginning the first article tests. The first article test report must be approved by the qualifying activity, or the procuring activity may require that the qualifying activity perform the first article tests. The qualifying activity shall have cognizance over first article tests performed under this specification when required by, and on an advisory basis to, the procuring activity.

- 3.2.1 First article (Class 1-NVIS Green A): Class 1-NVIS Green A panels shall meet the first article requirements of MIL-L-85762. The first article test procedures shall be approved by the qualifying activity prior to beginning the first article tests. The first article test report must be approved by the qualifying activity and shall meet the data item description (DID) requirements of MIL-L-85762. The procuring activity may require that the qualifying activity perform the first article tests. The qualifying activity shall have cognizance over first article tests performed under this specification when required by, and on an advisory basis to, the procuring activity.

3.3 Design:

Panel design shall meet the classification requirements of 1.2.

3.4 Construction:

The panel shall be constructed to meet the criteria set forth in this specification.

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- 3.4.1 Materials and parts: Except for surface finishing, electrical circuitry, connectors, and sealants, the panels shall be made of transparent plastic in accordance with MIL-P-5425, finish A, or molding compound conforming to L-P-380, Type II, Class 3. The dielectric requirements of L-P-380 are waived. Panels shall be annealed to remove stresses and to prevent warpage from occurring after environmental stresses. Under special circumstances panels may be fabricated from other materials subject to approval by the procuring agency when advised by the qualifying activity.
- 3.4.2 Panel thickness: Panels shall be 0.230 +/- 0.023 inch (5.842 +/- 0.584 millimeters) thick and shall be 0.047 +/- 0.016 inch (1.194 +/- 0.406 millimeters) smaller in the length and width dimensions than the mounting plate. The Type V and VII panel, however, shall have the printed circuit board recessed within the plastic panel so that the backs of the plastic panel and the circuit board are flush to 0.010 inch (0.254 millimeter) above flush. The maximum thickness of the Type V and VII panels with over flush circuit boards shall not exceed 0.253 inch (6.426 millimeters).
- 3.4.3 Lamps: Lamps may be incandescent, LEDs, or electroluminescent. The incandescent lamps shall meet the requirements of MIL-L-6363 (including vibration) and one of the following appropriate drawings: MS24367, MS24515, MS90451, or MS90452. LED lamps may be either hermetic or plastic encapsulated packages, with leads for either through hole or surface mount assembly. The LED lamps should be selected for light output and color and undergo reliability screening as may be deemed necessary by the procuring activity. Reliability screening shall be performed in accordance with either MIL-S-19500, MIL-D-87157, or as detailed in the LED lamp specification drawing.
- 3.4.3.1 Lamp embedment: Panels are constructed with either incandescent, LEDs, or electroluminescent lamps contained within and recessed a minimum distance from the front and rear surfaces of the panel. All lamps shall be protected by a minimum of 0.030 inch (0.762 millimeter) of plastic between the lamp and the front face of the panel. Electroluminescent lamps shall be contained within and recessed a minimum of 0.050 inch (1.270 millimeters) from the rear surface of the panel. The back of the panel shall be opaque black or the same opaque color as the background of the front of the panel; in either case, the back of the panel shall not permit stray light leakage. All incandescent lamps and associated lamp circuitry (except for Type V panels) shall be recessed from the rear surface of the panel and covered with a minimum of 0.020 inch (0.508 millimeter) film of non-conductive resin. The resin shall not protrude above the rear surface of the panel. The resin film shall be mechanically and chemically compatible with the panel and lamp circuit materials. The resin shall be resilient to permit expansion and contraction of the lamp glass without cracking the glass and without lamp failure. Conformal coatings of silicone rubber may be used to act as a buffer between the lamp and more rigid resins.
- 3.4.3.2 Lamp quantity: Types III, IV, and V panels shall employ at least two incandescent lamps and shall be so designed that the failure of any one lamp does not reduce the luminance of the markings by more than the values specified in 3.8.5. Unless otherwise specified by the procuring activity:
- Type IV panels should be restricted to not more than ten lamps.
 - If more than ten lamps are required than a Type V panel design should be used.
 - Type VI panels may employ one or more electroluminescent lamps.

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3.4.3.2 (Continued):

(d) Type VII panels should employ at least two LED lamp assemblies per electrical circuit configuration with at least two separate electrical circuit configurations per panel that are connected in parallel or series/parallel combinations and that compensate for the polarity and direct current characteristics of LED's.

3.4.3.3 Printed circuit board (Types V and VII): Circuit boards shall conform to MIL-P-13949, Type GFP028C2-xxx as a minimum. The preferred circuit is to leave most of the copper foil intact on the circuit board. The design of the conductor pattern shall provide large areas of copper or solder clad copper (for Type V and Type VII panels with electronic circuitry) separated only by non-conducting gaps (0.020 inch or 0.508 millimeter minimum) rather than narrow ribbons of copper conductor. The conductor pattern shall have a minimum clearance of 0.050 inch (1.270 millimeters) from all circuit board edges, holes, and cutouts except for the electrical connector. An organic protective coating in accordance with MIL-I-46058 shall be applied to the conductor side of the circuit board after installation of the lamps and connector. The coating shall cover all exposed metal parts but not the glass envelopes of the lamps. The conductors shall be free from contamination such as corrosion, stains and solder flux before coating. A sufficient number of 2-56 screws to hold all areas of the circuit board flush to the plastic panel shall be provided. The printed circuit board shall be opaque black and shall not permit light leakage through or from the edges of the printed circuit board.

3.4.3.3.1 Printed circuit board (Types V and VII, Class 1-NVIS Green A): The exterior side of the circuit board that serves as the back of the panel shall NOT emit or transmit energy that is viewable with night vision imaging system (NVIS) devices or exceeds the NVIS radiance (NR) levels of MIL-L-85762. In addition, a sufficient number of 2-56 screws shall be provided to hold all areas of the circuit board flush to the plastic panel without allowing the leakage emission of stray light. The circuit board shall not exhibit degradation in compliance with MIL-L-85762 after exposure to the environmental tests.

3.4.3.4 Lamp circuit: The lamp circuit shall consist of conductive material with a resistivity not greater than pure copper (20°C) with a minimum cross sectional area of 254 circular mils (see 6.12.2 and 6.13). All conductor circuit material shall be soldered to the lamp leads and the electrical connector. Soldering shall be in accordance with MIL-STD-2000. Electrical circuitry shall comply with requirement 1 of MIL-STD-454. The connector center pin shall be the positive terminal in accordance with MS90335. The type and number of lamps used in Type IV, V, VI and VII panels shall be marked on the rear surface of the panel or circuit board in such a way as not to interfere with the lighting.

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- 3.4.3.4.1 Incandescent lamp circuit: Unless specified otherwise by the procuring activity, incandescent lamp circuits shall operate from a 5-volt power source. All lamps shall be connected in parallel terminating in an electrical connector. When special circumstances require the use of a 28-volt lamp power source, the first construction option shall be 5-volt lamps arranged in combination series-parallel circuits and soldered to a separate circuit board. The series-parallel lamp circuit shall be designed to intermix the lamps of the series circuits throughout the panel to maximize the maintenance brightness when a lamp string fails. When lamps are connected in series, consideration should be given to selecting these lamps in tight current ranges so that the voltage will divide evenly between all lamps in a series string. If the panel is too small for this arrangement, a second option shall be 28-volt based lamps removable from the front of the panel. However, incandescent lamp circuits with T1 and T1 3/4 front relampable light assemblies are not recommended due to the proliferation of nonstandard lamp assemblies, the short lamp life, and the intermittent lighting problems that can occur due to vibration and adverse environments. Configurations using 28-volt unbased lamps soldered to a circuit board should be avoided due to short lamp life. Embedding of unbased 28 volt lamps is not acceptable.
- 3.4.3.4.2 LED lamp circuit: LED lamps may be electrically connected in parallel or in series/parallel combinations provided compensation is made for the polarity and direct current characteristics of LED's (for instance, a LED lamp may be defined to consist of two LED's in electrical parallel where one LED is forward biased and one is reversed biased; that is, the cathode of the first LED connected to the anode of the second LED, and the anode of the first LED connected to the cathode of the second LED). Each individual LED lamp connected in parallel and each string of LED lamps connected in series/parallel combination shall have appropriate current limiting. Panels with LED lamps connected only in parallel shall be operated from a 5-volt ac power source. Panels with LED lamps connected in series/parallel combinations may be operated from either a 5-volt or a 28-volt ac power source, as determined by the internal LED circuit configuration. Luminance dimming by reducing LED drive current with reduction of applied voltage is preferred over pulse width modulation techniques that vary with applied voltage. The luminance versus voltage curve for a Type VII (LED) panel shall approximate that of a Type IV, V, or VI panel, depending on the application. If transient overvoltage and/or reverse voltage protection is required, the protection circuit shall be included in the internal circuit within the panel.
- 3.4.3.4.3 Circuit marking of panels: For Type IV panels, if all of the lamps and lamp circuits are not visible from the back of the panel, a white line shall be applied to the rear surface of the completed panel indicating the location of the lamp circuit. Areas occupied by the lamps shall be marked in a similar manner with a crosshatched or solid white area. For Class 1-NVIS Green A, the white paint shall meet the MIL-L-85762 NVIS radiance requirements when illuminated with compatible lighting per MIL-L-85762.

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- 3.4.3.5 Electrical connectors: Type IV and VI panels utilizing one electrical circuit shall use the MS90335-7 plug assembly and the collar shall extend 0.140 +/- 0.010 inch (3.556 +/- 0.254 millimeters) from the rear surface of the panel. Type V and VII panels utilizing one electrical circuit shall use the MS90335-8 plug assembly and the collar shall extend 0.135 +/- 0.010 inch (3.429 +/- 0.254 millimeters) from the rear surface of the panel. The MS90335-8 plug assembly, when soldered to the circuit board, shall be capable of withstanding a force of 15 pounds (67 Newtons) applied to the collar of the assembly in a direction perpendicular to the board. The connector shall be mounted so that the electrical circuitry of the panel is disconnected from the power source by removal of the panel, center pin recessed, i.e. MS90335 type connector. The connector mounting provisions shall not protrude beyond the rear surface of the panel or circuit board.
- 3.4.3.5.1 Connectors: Connectors of the MS90335 type as used in qualification panels and production panels as defined in this specification shall meet all dimensional and other requirements of MS90335.
- 3.4.3.5.2 Connector location: A white, nonilluminated cross (+) approximately 0.08 inch (2.032 millimeters) by 0.08 inch (2.032 millimeters) shall be centered and located on the front surface of the panel approximately above the electrical connector. The centering and location of the connector may require deviation when required nomenclature interferes with the marking. For Class 1-NVIS Green A, the white paint shall meet the NVIS radiance (NR) requirements of MIL-L-85762 when illuminated with compatible lighting per MIL-L-85762.
- 3.4.4 Rated voltage (test purposes): The rated operating voltage for Type VI panels shall be 115 +/- 2 volts ac rms at 400 +/- 5 hertz. The rated operating voltage for Type IV, V and VII panels shall be as follows:

<u>Class</u>	<u>Types IV, V and VII</u>
1-R, 2-R	5.0 +/- 0.05
1-W, 2-W	5.0 +/- 0.05
1-BW, 2-BW	4.5 +/- 0.05
1-NVIS Green A	5.0 +/- 0.05

The luminance requirements for 28 volt lamps shall be met at 28.0 +/- 0.1 volts. The rated voltage for Type VII panels shall be either 5 volts or 28 volts depending upon the internal LED circuit wiring configuration. For test purposes, all lamps shall be operated from direct current (DC), except for Type VI panels.

- 3.4.5 Mounting: The panels shall be designed to permit removal without disturbing components thereof, except for knobs, lampholders and hold-down fasteners.
- 3.4.5.1 Grommets: Grommets of the MS3498 type as used for production panels as defined in this specification shall meet all dimensional and other requirements of MS3498.

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3.4.5.2 Fasteners: Fasteners shall consist of 6-32 machine screws. A fastener for each 8 square inches (5161.3 square millimeters) of surface area shall be provided. No fewer than two screws shall be used. The panel shall have provisions, such as MS3498 grommets, to prevent it being crushed by the screws. Spacing symmetry of the fasteners shall be such as to minimize warpage affecting the operation of the controls.

3.4.5.3 Movement: Movement of the panel shall not expose any lighted area not normally exposed when the panel is correctly installed. When marks on a knob or knob skirt and marks on the panel are required, any movement of the panel shall not change the position of markings so as to exceed the tolerance required for proper interpretation of the control.

3.5 Circuit continuity - Types IV and V:

The panel under test shall be energized and visually examined to determine that each lamp is illuminated in accordance with applicable military specification drawings (including current) and as specified by the procuring activity.

3.6 Insulation resistance - Types IV, V, VI and VII:

The panel leakage current measured in accordance with 4.5.4 shall not exceed 50 microamperes.

3.7 Finish:

Each panel produced shall be finished so as to comply with the requirements of this specification.

3.7.1 Surface coating: Except for the markings, those areas required for lighting functions, and the circuit board in Type V and VII panels, all surfaces of each panel shall be opaque and shall be the color specified in 3.7.2.1 for the background of the front of the panel.

3.7.2 Background colors: The background colors shall meet 3.7.2.1. The background of the front side of each Class 1 panel shall be finished with black. The background of the front side of each Class 2 panel shall be finished with gray. The markings on each panel shall be finished with white. Immediate action stripes shall be finished with yellow for non-NVIS panels and with alternating yellow, black, and white stripes for Class 1-NVIS Green A panels. The yellow shall be transilluminated for non-NVIS panels and shall not be illuminated for Class 1-NVIS Green A panels. The external finish of any lampholder and attaching hardware shall correspond to the background color of the panel.

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- 3.7.2.1 Color of finishes: Finishes shall conform to FED-STD-595 for the following colors when examined under a “cool white” fluorescent illumination (CIE illuminant F2):

<u>Color</u>	<u>Color Number</u>
Black	37038
Gray	36231
White	37875 or 37925
Yellow	33538

NOTE: Only White Color number 37925 is permissible for Class 1-NVIS Green A and it SHALL BE UNTINTED as implied by FED-STD-595. Tinting shall not be used to achieve a match with White Color number 37925. FED-STD-595 White Color Number 37875 often has red or other tinting pigments introduced by the paint manufacturer for color chip matching that are incompatible with MIL-L-85762.

- 3.7.2.2 Color of finishes (Class 1-NVIS Green A): When finish materials are illuminated with NVIS compatible lighting, the resulting emissions shall not exceed the NVIS radiance limits of MIL-L-85762 whether before or after environmental tests.

3.8 Legends and marking:

The legends and markings on the panel shall conform to MIL-M-18012. The marking shall not be deeper than 0.005 inch (0.127 mm). All markings shall be sharply defined and readable when viewed at any angle up to and including 60 degrees from the normal to the plane of the front face of the panel.

- 3.8.1 Legend color: The lettering, numbering, and (except for yellow immediate action stripes) the marking of the plastic lighting panel shall be Fed-Std-595, color number 37875 or 37925 (for Class 1-NVIS Green A) when examined under a “cool white” fluorescent illumination (CIE illuminant F2) and when the lighting units are not energized. For Class 1-NVIS Green A, the yellow immediate action stripes are to be replaced with alternating yellow, black, and white stripes where lighting shall only transilluminate the white stripes.
- 3.8.2 Contrast: The daylight contrast between markings, legends, and indicia and the background on the panel shall be determined with the panel lighting system inoperative and in accordance with 4.5.5. Contrast C is defined as:

$$C = \frac{B_2 - B_1}{B_1}$$

where B_1 is the average luminance of the background immediately surrounding the marking and B_2 is the average luminance of the marking. The contrast value shall be at least 9 for Class 1 panels and 2.5 for Class 2 panels.

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3.8.3 Luminance of markings: The luminance of all markings on the panels and associated knobs, dials, etc., when illuminated by the integral lighting system and at the rated voltage (3.4.4) only, shall be as follows:

<u>Panel Type</u>	<u>Class</u>	<u>Luminance of Marking (Footlambert)</u>	<u>Luminance of Marking (cd/m²)</u>
III	1-R & 2-R	0.6 +/- 0.4	2.1 +/- 1.4
	unfiltered White	3.0 +/- 2.0	10.3 +/- 6.9
	1-NVIS Green A	0.6 +/- 0.4	2.1 +/- 1.4
IV, V, VI, and VII	1-R & 2-R	1.0 +/- 0.5	3.4 +/- 1.7
	1-W & 2-W	2.0 +/- 1.0	6.9 +/- 3.4
	1-BW & 2-BW	1.0 +/- 0.5	3.4 +/- 1.7
	1-NVIS Green A	1.0 +/- 0.5	3.4 +/- 1.7

3.8.3.1 Luminance (Type III): Each Type III panel shall meet the specified illumination requirements with MS25237 lamps operating at 0.34 +/- 0.02 spherical candela installed in each lampholder.

3.8.4 Illumination legends: Illuminated legends on an integrally illuminated information panel and of a warning, caution, or advisory nature shall meet the requirements of MIL-STD-411 whenever the activation signal is separate from the lighting system power.

3.8.5 Luminance maintenance: In the event of a lamp failure, the luminance of any marking depending on the incandescent, LED, or electroluminescent lamps and the associated circuitry (see 3.4.3.4 and subparagraphs) shall not be reduced below the minimum listed at the rated voltage (3.4.4):

<u>Panel Type</u>	<u>Class</u>	<u>Minimum Luminance (Footlambert)</u>	<u>Minimum Luminance (cd/m²)</u>
IV, V, and VII	1-R & 2-R	0.15	0.51
	1-W & 2-W	0.50	1.7
	1-BW & 2-BW	0.20	0.69
	1-NVIS Green A	0.15	0.51
VI (after 1200 hours)	1-R & 2-R	0.30	1.0
	1-W & 2-W	0.50	1.7
	1-BW & 2-BW	0.30	1.0
	1-NVIS Green A	0.30	1.0

The minimum luminance of all markings on Type VI panels and associated knobs, dials, etc., shall be capable of providing the above minimum luminance after 1200 hours of continuous operation at rated voltage in an environment of 70°F and a relative humidity not to exceed 80 percent.

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- 3.8.5.1 Failed lamp - Type IV, V and VII Qualification Panels (except front relampable): One of the Type IV, V and/or VII panels shall have rigid individual electrical posts or connectors (not bare or insulated wires) for each lamp brought out of the rear surface of the panel. However, the electrical common for each lamp shall still terminate in the MS90335 connector. An alternate approach is to use a switch block with dip switches that permit each lamp to be individually switched on/off.
- 3.8.5.2 Type V front relampable: When MS24515 or MS3338 based lamps are used with hardware permitting replacement of the lamps from the front face of the panel, the luminance requirements of 3.8.5 do not apply.

3.9 Color of light:

The light transmitted through the panel markings, legends, and indicia and all elements illuminated by the panel shall meet the following requirements when the lighting system is operated at the rated voltage (see 3.4.4) as measured at the panel connector (except that NVIS Green A shall be at the necessary voltage to produce 0.1 footlambert (0.3 cd/m^2)):

<u>Class</u>	<u>Chromaticity Requirements</u>
1-R & 2-R	IPL Red, Type 1f of MIL-C-25050
1-W & 2-W	IPL White, Type 1g of MIL-C-25050
1-BW & 2-BW	Blue-Filtered White, Type 1h of MIL-C-25050
1-NVIS Green A	NVIS Green A of MIL-L-85762 at 0.1 footlambert

The light transmitted through the white portion of Class 1-NVIS Green A immediate action stripes (3.7.2) shall also meet the above chromaticity requirements but the yellow portion shall not be illuminated.

3.10 NVIS radiance (Class 1- NVIS Green A):

The light transmitted through the panel markings, legends, and indicia and all elements illuminated by the panel shall meet the NVIS radiance requirements of MIL-L-85762 for NVIS Green A when the lighting system is operated at the rated voltage (see 3.4.4) as measured at the panel connector and when scaled for 0.1 footlambert (0.3 cd/m^2). NVIS radiance shall be measured in accordance with 4.5.8.

3.11 Light leakage (Class 1-NVIS Green A):

Each panel under test shall be examined front, back, and sides in a dark environment in accordance with MIL-L-85762 for light leaks. The image intensifier device shall meet the performance characteristics of 6.5.1.4.

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3.12 Gloss:

The gloss of the background of the panel shall not exceed 5 units when measured in accordance with 4.5.10.

3.13 Environmental tests:

The panels shall maintain the requirements for circuit continuity (3.5), insulation resistance (3.6), contrast (3.8.2), luminance (3.8.3), color (3.9), light leakage (3.11), NVIS radiance (3.10), and gloss (3.12) before and after exposure to the environmental tests. These environmental tests are performed without power supplied to the panel.

3.13.1 Accelerated weathering: The panels shall be subjected to the accelerated weathering test (4.5.11) for 150 hours in accordance with an accelerated weathering chamber as described in ASTM G26, Type BH, Test Method 1.

3.13.2 Altitude: The panels shall be subjected to the altitude test of 4.5.12 when tested in accordance with Method 105 of MIL-STD-202 for 30 minutes at an altitude of 100,000 feet (30,400 meters) which corresponds to 0.32 inch (8.128 mm) of mercury (Hg).

3.13.3 Salt Fog: The panels shall be subjected to the salt fog test of 4.5.13 when tested in accordance with Method 101 of MIL-STD-202 for 26 hours.

3.13.4 Humidity: The panels shall be subjected to the Humidity Test of 4.5.14 for ten cycles in accordance with Procedure III and Figure 507.3-3 of Method 507 of MIL-STD-810.

3.13.5 Temperature: The panel shall be capable of withstanding five cycles of temperature shock where each cycle consists of a one hour soak time at -65°C (-85°F), a maximum 3 minute transition between -65°C (-85°F) and $+85^{\circ}\text{C}$ ($+185^{\circ}\text{F}$), and a one hour soak time at $+85^{\circ}\text{F}$ when performed in accordance with 4.5.15.

3.13.6 Radiated emissions (Type VII): Type VII panels that use pulse width modulation techniques for luminance dimming shall meet the applicable radiated emissions requirements of RE01 and RE02 of MIL-STD-461 when tested in accordance with 4.5.19.

3.13.7 Random vibration (Type VII): Type VII panels that use pulse width modulation techniques for luminance dimming shall meet the random vibration requirements of 4.5.20. there shall be no visually perceptible change or degradation in luminance, color, or NVIS radiance.

3.13.8 Sinusoidal vibration (Type VII): Type VII panels that use pulse width modulation techniques for luminance dimming shall meet the sinusoidal vibration requirements of 4.5.21. There shall be no visually perceptible change or degradation in luminance, color, or NVIS radiance.

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3.14 Solvents and Fluids:

The surface finish of the panel shall not exhibit degradation when subjected to the solvents and fluids test of 4.5.16 both before and after exposure to the environmental tests. Felt pads meeting the requirements of C-F-206 are to be saturated with the following: Lacquer Thinner meeting the requirements of TT-T-266; Engine Oil of Grade 1010 meeting the requirements of MIL-L-6081; Grease Cleaning Compound meeting the requirements of P-C-444; and Hydraulic Fluid meeting the requirements of MIL-H-83282. Upon test completion, the panels should be cleaned with lacquer thinner and mild soap and water.

3.15 Surface endurance:

The panel shall be capable of withstanding the surface endurance test of 4.5.17 both before and after exposure to the environmental tests.

3.16 Keyboard and keypad assemblies:

Integral panel keyboard and keypad assemblies with both illuminated panel and button markings, with illuminated keyboard or keypad buttons only, and integral placard assemblies with non-illuminated keyboard buttons shall meet the requirements for background colors (3.7.2 and subparagraphs), legends and markings (3.8 and subparagraphs), contrast (3.8.2), luminance (3.8.3), luminance maintenance (3.8.5), color coordinates (3.9), and when applicable, NVIS radiance (3.10) and light leakage (3.11). These requirements are not applicable for conventional push button switches meeting the requirements of MIL-S-22885 or MIL-S-38039. The design, construction, and dimensional requirements of the source control drawings may take precedence over 3.3, 3.4, and subparagraphs.

3.17 Identification of product:

The panels shall be marked for identification in accordance with MIL-STD-130. The minimum identification data shall be as follows but need not be in the same order or all located in one area of the panel:

- (a) Contractor and Government Entities (CAGE)
- (b) NSN 6220***
- (c) Panel manufacturer's name and process designation
- (d) Panel manufacturer's CAGE code; the panel manufacturer's or design activity part number (as applicable); and the design activity CAGE code and part number (as applicable).
- (e) Month and year manufactured

The identification data shall be marked on the back of each panel in such a manner as not to interfere with lighting or mounting.

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3.18 Interchangeability:

All parts having the same panel manufacturer's part number shall be functionally and dimensionally interchangeable. The drawing number requirements of DOD-D-1000 shall govern changes in the manufacturer's part number. All Type V and Type VII panel circuit boards of the same manufacturer's part number shall be physically and dimensionally interchangeable without requiring any light balancing or toning of the plastic panel or circuit board within the limitations imposed by the intensity tolerances of the MS lamps, electroluminescent lamps, and LED lamps used.

3.18.1 NVIS Radiance (Class 1-NVIS Green A): The NVIS radiance requirements of 3.10 shall continue to be met whenever the interchangeability requirements of 3.18 are invoked.

3.19 Performance:

The panels shall perform satisfactorily when subjected to the test requirements specified in Section 4.

4. QUALITY ASSURANCE PROVISIONS:

4.1 Responsibility for inspection:

Unless otherwise specified in the contract or purchase order, the supplier is responsible for the performance of, and the compliance with, all inspection requirements as specified herein. Except as otherwise specified, the supplier may utilize his own facilities or any commercial laboratory acceptable to 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 that 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 inspection 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 all products or supplies to the Government for acceptance comply with all requirements of the contract. Quality Conformance Sample testing does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

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

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4.1.3 Test procedures: The procedures used for conducting all required tests shall be prepared by the contractor and submitted to the acquiring activity or authorized agent for review and approval. The right is reserved by the Government to modify the test or require any additional tests deemed necessary to determine compliance with the requirements of this specification or the contract. Specification MIL-T-18303 shall be used as a guide for preparation of test procedures. When approved test procedures are available from previous contracts, such procedures will be provided and may be used when their use is approved by the acquiring activity. However, the right is reserved by the acquiring activity to require modification of such procedures, including additional tests, when deemed necessary.

4.2 Classification of inspections:

The inspection and testing of integrally illuminated information panels shall be classified as follows:

- (a) Qualification tests. Qualification tests are the Group I tests of Table I as performed on sample panels made in accordance with Figure 1 of this specification and submitted for qualification of a manufacturer's process.
- (b) Acceptance tests. Acceptance tests are the Group II tests of Table I as performed on individual production products or lots which have been submitted under contract to determine conformance of the products or lots with requirements set forth in the specification prior to acceptance.
- (c) Quality conformance inspection. The quality conformance inspection shall consist of the Group III tests of Table I to determine conformance with the environmental and performance requirements set forth in this specification. Tests are performed on a few samples based upon production quantities or time period. Samples subjected to Group III tests shall not be issued because they are tested to destruction.

4.2.1 Qualification testing: A sample for qualification testing shall consist of six identical panels conforming to Figure 1 and shall be made using a given manufacturing process. One of those six panels for Type IV and V shall be configured on the back to meet 3.8.5.1. Multiple processes may require a reduced number of samples when authorized by the qualifying activity.

NOTE: The term "process", as used in this context, is defined as the total manufacturing plan, including materials and techniques by which panels are fabricated.

4.2.1.1 MS90335 connector qualification: Ten samples of the MS90335 plug assembly as used with qualification test panels shall also be furnished with the qualification panels. These samples shall be inspected for dimensional, finish, and performance requirements of MS90335. However, if the MS90335 plug assemblies have been previously qualified, a Certification of Qualification may be submitted in lieu of samples. Manufacturers of MS90335 connectors may obtain qualification by the same procedure outlined herein for panels, except that the samples of each connector shall be submitted and requirements are controlled by MS90335.

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TABLE I: QUALIFICATION, CONFORMANCE, AND SAMPLE TESTING

INSPECTIONS		REQUIREMENT PARAGRAPH	TEST PARAGRAPH	GROUP I QUAL TESTS	GROUP II QUALITY CONFORMANCE TESTS	GROUP III SAMPLE TESTS PER 4.5.1
EXAMINATION OF PRODUCT	VISUAL DEFECT	3.8.1		X	X	X
	FINISH COLOR	3.7	4.5.1	X	X	X
	DIMENSIONAL MEAS./CONTROLS	3.5.2.5		X	X	X
		3.8.2		X	X	X
CIRCUIT CONTINUITY	3.5	4.5.3	X	X	X	
INSULATION RESISTANCE	3.6	4.5.4	X	X	X	
PHOTOMETRIC BASELINE TESTS	CONTRAST	3.8.2	4.5.5	X	X	X
	BRIGHTNESS	3.8.3	4.5.6	X	X	X
	COLOR OF LIGHT	3.9	4.5.7	X	X	X
	NVIS RADIANCE	3.10	4.5.8	X	X	X
	LIGHT LEAKAGE	3.11	4.5.9	X	X	X
	GLOSS	3.12	4.5.10	X	X	X
ENVIRON- MENTALS	ACCEL. WEATHER	3.13.1	4.5.11	X		X
	ALTITUDE	3.13.2	4.5.12	X		X
	SALT FOG	3.13.3	4.5.13	X		X
	HUMIDITY	3.13.4	4.5.14	X		X
	TEMPERATURE	3.13.5	4.5.15	X		X
	EMI EMISSIONS	3.13.6	4.5.19	X		X
	RANDOM VIBRATION	3.13.7	4.5.20	X		X
	SINE VIBRATION	3.13.8	4.5.21	X		X
POST ENVIRON- MENTAL TESTS	CONTRAST	3.8.2	4.5.5	X		X
	BRIGHTNESS	3.8.3	4.5.6	X		X
	COLOR OF LIGHT	3.9	4.5.7	X		X
	NVIS RADIANCE	3.10	4.5.8	X		X
	LIGHT LEAKAGE	3.11	4.5.9	X		X
	GLOSS	3.12	4.5.10	X		X
	CIRCUIT CONTINUITY	3.5		X		X
	INSULATION RESISTANCE	3.6		X		X
FAILED LAMP	3.8.5	4.5.6.1	X			
SURFACE ENDURANCE	3.15	4.5.17	X		X	
SOLVENTS AND FLUIDS	LACQUER THINNER			X		X
	ENGINE OIL			X		X
	HYDRAULIC FLUID	3.14	4.5.16	X		X
	GREASE CLEANER			X		X
TYPE V, VII PC BOARD DESIGN		3.4.3.3				
		3.4.3.4	4.5.18	X		X
		3.4.3.5				
NVIS Interchange ability	3.18.1	4.5.8 4.5.9	X		X	

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4.2.1.2 Lamp certification: A certificate of conformance or a test report shall be furnished with the qualification test panels to show compliance with MIL-L-6363 and the appropriate lamp MS drawings. For LED lamps, the specification drawings and the certification of any reliability testing shall be provided for the types of LED lamps used.

4.2.1.3 Qualification samples: Samples, along with evidence in the form of a test report showing that the process being submitted has met the requirements of the specification (Group II Quality Conformance Tests of Table I, unless the qualifying activity requests Group I Qualification Tests of Table I), shall be forwarded to the testing laboratory designated in the letter of authorization from the activity responsible for qualification (see 6.3), and the panels shall be plainly identified by securely attached, durable tags with the following information.

PANEL, INFORMATION, INTEGRALLY ILLUMINATED, Type and Class,
Manufacturer's process identification, Submitted by (name of manufacturer) (date) for qualification tests in accordance with MIL-P-7788F under authorization (reference letter authorizing tests). NOTE: These panels may be tested to destruction and are not returnable.

Qualification approval shall extend for a two year period, except that requalification may be required at any time the vendor undergoes a name change, moves his manufacturing plant to a new address, undergoes a material or process change, or undergoes management changes at the manufacturing plant. The vendor will be allowed four months from the date of his move to submit qualification panels made at the new location.

4.2.1.3.1 Retention of qualification samples: At the end of the aforementioned two year qualification approval period, the contractor must submit two samples of each type and class in order to retain qualification listing on the Qualified Products List (QPL) for an additional two year period. As a minimum, these retention samples will be subjected to the tests described in 4.2.1.4.1 Retention tests. At the discretion of the qualifying activity, retention by similarity may be permitted in a manner similar to that described in 3.1.2 Qualification by similarity. In addition, as a minimum, the contractor must satisfactorily complete a Form DD 1718 (Certification of Qualified Products) as well as an Illumination Test Facility Certification Report, certified by QAR.

4.2.1.4 Tests: The qualification tests shall consist of all of the tests of this specification, as described under 4.5, except Arrangement of Controls 4.5.2, and shall be performed in the order shown in Table II.

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TABLE II. Test Sequence

<u>Test</u>	<u>Sample # --></u>	1	2	3	4	5	6
(1) Examination of Product (4.5.1)		x	x	x	x	x	x
(2) Circuit Continuity (4.5.3)		x	x	x	x	x	x
(3) Insulation Resistance (4.5.4)		x	x	x	x	x	
(4) Contrast (4.5.5)		x	x	x	x	x	x
(5) Luminance (4.5.6)		x	x	x	x	x	x
(6) Luminance Maintenance (4.5.6.1)							x
(7) Color of Light (4.5.7)		x	x	x	x	x	x
(8) Class 1-NVIS Radiance (4.5.8)		x	x	x	x	x	x
(9) Class 1-NVIS Leakage (4.5.9)		x	x	x	x	x	x
(10) Gloss (4.5.10)		x	x	x	x	x	x
(11) Accelerated Weathering (4.5.11)		x	x	x	x		
(12) Altitude (4.5.12)		x	x				
(13) Salt Fog (4.5.13)				x			
(14) Humidity (4.5.14)		x	x		x		
(15) Temperature (4.5.15)		x		x			
(16) Type VII Radiated Emissions (4.5.19)		x		x			
(17) Type VII Random Vibrations (4.5.20)		x		x			
(18) Type VII Sinusoidal Vibration (4.5.21)		x		x			
(19) Contrast (4.5.5)		x	x	x	x		
(20) Luminance (4.5.6)		x	x	x	x		
(21) Color of Light (4.5.7)		x	x	x	x		
(22) NVIS Radiance (4.5.8)		x	x	x	x		
(23) NVIS Radiance Leakage (4.5.9)		x	x	x	x		
(24) Interchangeability (4.5.22)		x	x	x	x	x	x
(25) Gloss (4.5.10)		x	x	x	x		
(26) Circuit Continuity (4.5.3)		x	x	x	x		
(27) Insulation Resistance (4.5.4)		x	x	x	x		
(28) Lacquer Thinner (4.5.16)		x					
(29) Engine Oil (4.5.16)			x				
(30) Hydraulic Fluid (4.5.16)				x			
(31) Grease Cleaner (4.5.16)					x		
(32) Surface Endurance (4.5.17)		x	x	x	x		

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4.2.1.4.1 Retention tests: As a minimum, samples received for retention of qualification will be subjected to those tests listed as "GROUP II QUALITY CONFORMANCE TESTS" in Table I. The Government reserves the right to require additional testing if deemed necessary.

4.3 Test conditions:

4.3.1 Atmospheric conditions: Unless otherwise specified in the individual equipment specification, all inspections herein shall be performed at atmospheric pressure of 28 to 32 inches (711.2 to 812.8 millimeters) mercury (Hg) at a temperature of 21° +/- 3°C (69.8 +/- 5.4 °F), and a relative humidity of 80% or less.

4.3.2 Lighting conditions: Luminance, chromaticity and NVIS radiance measurements shall be made in a dark room where the ambient spectral radiant energy over the spectral range of 380 to 930 nanometers is either not measurable (equivalent to system noise) or no greater than 0.1% of the value of spectral radiant energy from the test sample being measured.

4.4 Quality conformance inspection:

Quality conformance inspection shall consist of the Group II tests as specified in Table I. Unless otherwise specified by the procuring activity, the contractor shall furnish samples and shall be responsible for performing the Group II tests under the cognizance of the Government Quality Control Representative. The contractor shall prepare and have available for review quantitative test results for the authorized Government Quality Control Representative. Acceptance or approval of material during the course of manufacture shall in no case be construed as a guarantee of the acceptance of the finished product. Group III tests of Table I shall be invoked whenever required by the procuring activity as advised by the qualifying activity.

4.4.1 Acceptance tests: Each Integrally Illuminated Information Panel submitted for acceptance shall be subjected to the Group II tests. These tests need not be performed necessarily in the order listed. These tests shall determine compliance with the requirements of design, construction, workmanship and operational accuracy. Whenever the panel fails any Group II or III tests of Table I, the production lot shall be rejected. As a minimum, each panel shall have passed the Group II tests of Table I.

4.4.1.1 Inspection lot: An inspection lot shall consist of all panels of the same type produced under essentially the same manufacturing conditions and submitted for inspection at the same time. The unit of product as defined in MIL-STD-105 shall be one panel.

4.4.1.2 Resubmitted inspection lot: Paragraph title "Resubmitted Lots" of MIL-STD-105 shall apply except that a resubmitted inspection lot shall be inspected by the contractor under the supervision of the Government Inspector using tightened inspection. Where the original acceptance number was zero, a sample size represented by the next higher sample size code letter shall be chosen. Before resubmitting, full particulars concerning the cause of previous rejection and the action taken to correct the defects found in the inspection lot shall be furnished by the contractor to the cognizant contracting office.

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- 4.4.2 Production Lot Sampling Tests (Class 1-NVIS Green A): All panel assemblies submitted for inspection as a production lot shall be manufactured using identical components, raw materials, and processes. Initially and at six month intervals, the procuring activity may (at the request of the qualifying activity) require the submission of one NVIS production panel for all Group III tests specified in Table I. This NVIS production panel is required to have passed the Group II inspection tests of Table I prior to submission. The sample unit shall be selected at random under the supervision of the cognizant government inspector and submitted to the qualifying activity. As a minimum, the qualifying activity shall perform the NVIS radiance test of 4.5.8 both before and after the environmental tests. Based upon the historical trend of these tests, the periodic basis may be increased or decreased as required.
- 4.4.3 Defective Information Panels: When a defective panel is detected, no items from those still on hand or later produced shall be accepted until the extent and cause of failure have been determined and appropriately corrected.
- 4.4.4 Other tests: The panels may be subjected to any other tests specified herein which the procuring activity considers necessary to determine conformance to this specification. The process employed shall have passed the qualification tests. Three copies of the drawings showing layout, components to be illuminated by the panel, dimensions, details of marking, and types of knob used on controls shall have been submitted to, and approved by, the procuring activity. The illumination test facility to be employed for illumination tests shall have been approved by the activity responsible for qualification (6.5).
- 4.5 Test Methods:
- 4.5.1 Examination of product: Each panel submitted for acceptance shall be examined to determine conformance with applicable drawings and with each of the requirements of Section 3 (and subparagraphs) that can be inspected in this manner. Workmanship shall be examined thoroughly to insure compliance with the appropriate requirements with respect to materials [including 3.3, 3.4.1, 3.4.3 (and subparagraphs)], markings (3.8), outline dimensions, connectors [including 3.4.3.5 (and subparagraphs)], finish (3.7 and subparagraphs), display and assembly using appropriate measuring tools.
- 4.5.1.1 Color of finishes: Finishes shall meet 3.7.2.1 when tested in accordance with ASTM D1729.
- 4.5.2 Arrangement of controls: The panel shall be examined to determine that the controls and their arrangements are in accordance with the applicable drawings or as specified by the procuring activity.
- 4.5.3 Circuit continuity (Types IV and V): The panel shall meet the requirements of the appropriate MS drawing as required by 3.4.3 and 3.5.

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- 4.5.4 Insulation resistance (Types IV, V, VI and VII): The panel shall meet the requirements of 3.6. The panel shall be fastened to a conductive metal backplate having minimum dimensions equal to those of the panel. The backplate shall have clearance holes for all electrical connectors. A potential of 500 volts AC, 60 Hz, shall be applied between the backplate and all pins on the connector for 60 seconds. A potential of 500 volts DC shall then be applied between the backplate and each of the pins on the connector. The leakage current shall not exceed the requirements of 3.6.
- 4.5.5 Contrast: The measuring apparatus shall consist of a suitable photometer and light source (Figure 3) meeting the characteristics of 6.5.1.1. The front of the panel shall be perpendicular to the optical axis of the photometer. The panel shall not be energized. Illumination of the panel shall be provided by a uniform diffuse artificial illumination adjusted for approximately 50 footcandles. The luminance of the markings and of the background adjacent to these indicia shall be measured. The contrast shall be calculated according to and shall meet the requirements of 3.8.2.
- 4.5.6 Luminance test method: The panel shall be tested for compliance with 3.8.3 and 3.8.5 with a photometer that meets the characteristics of 6.5.1.1. The front surface of the panel shall be perpendicular to the line of sight of the photometer. The lamps shall be aged, tested, installed and operated as specified in 3.4.3 and on the applicable MS drawing. Tests shall be conducted in a dark room meeting the requirements of 4.3 and 6.5.1.7. The luminance of markings, legends, and indicia on the panel and markings on illuminated knobs which are required for proper interpretation of the knob function shall be measured to determine compliance with 3.8.3 and 3.8.5. Minimum and maximum luminance values shall be measured. Maximum and minimum luminance shall first be determined visually by reducing the panel voltage from rated conditions until the dimmest markings visually disappear. Continue to reduce the voltage until the brightest markings visually disappear. Return the panel to the rated test voltage of 3.4.4 and photometrically measure the luminance of the brightest and dimmest markings, as determined by the above visual inspection, using the measurement points of Figure 4 as a guide. The measured spot sizes shall be no less than 50% and no greater than 80% of the character stroke width. The luminance values to be reported shall be an average of three measurements for each character, except that any single measurement more than 20 percent above or below the 3.8.3 or 3.8.5 requirements shall constitute failure.
- 4.5.6.1 Failed lamp - Type IV, V, and VII Qualification panels (except front relampable): The lamps shall be de-energized in random sequence, one at a time, on the test panel that has been configured according to 3.8.5.1. While a lamp is de-energized, the luminance of markings depending partially on the de-energized lamps for illumination shall be measured and shall meet the requirements of 3.8.5.

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4.5.6.2 Luminance measurements (all types): Comparison of photometric luminance measurements by approved illumination test facilities should take into account tolerances inherent in the light measurement technique prescribed herein. For example, where the panel manufacturer certifies the illumination as being within the limits shown under Column "M" below, then the procuring activity shall accept the panels, provided his approved illumination test facility measures the luminance as being within the limits shown under column "P". In any event, the total spread in the luminance data shall not exceed the tolerances specified in 3.8.3.

Color of Light (Classes)	"M" Footlamberts	"P" Footlamberts	"M" cd/m²	"P" cd/m²
1R and 2R	0.5 to 1.5	0.47 to 1.58	1.7 to 5.1	1.61 to 5.41
1BW and 2BW	0.5 to 1.5	0.47 to 1.58	1.7 to 5.1	1.61 to 5.41
1W and 2W	1.0 to 3.0	0.95 to 3.20	3.4 to 10.3	3.25 to 10.96
1-NVIS Green A	0.5 to 1.5	0.47 to 1.58	1.7 to 5.1	1.61 to 5.41

4.5.7 Color of light: The panel shall meet the color of light requirements of 3.9 while satisfying the legend color requirements of 3.8.1. The color of the light (except Class 1R and 2R) emitted by the panels may be measured by either four filter colorimetry or by a spectroradiometric method depending upon the type, class, or means used to generate the color of light. The locations selected for test shall be determined by visual examination of the panel in a darkened environment and selecting those areas that appear to differ from the average color of the panel.

4.5.7.1 Four filter colorimetry: The photometer shall be certified as meeting the requirement of 6.5.1.1(i) and shall be calibrated using similar spectral distributions as the class of panels being measured. Four filter colorimetry is a better (though not the best) method for Types IV, V, VI, and VII all classes (except Class 1R and 2R). The photometer used for this test shall be certified to accuracies within +/- 0.005 in x and y. The accuracies for this method can be enhanced by calibration against a spectroradiometer for one data point on the panel to generate the appropriate correction factors specific for that panel. This enhancement is required whenever light emitted by LEDs, electroluminescent lamps and/or incandescent lamps have their spectral distribution changed due to paint-filter thicknesses and differing phosphor mixes to raise their apparent color temperature. The greater the change in color coordinates the greater the changes in correction factors to achieve correlation with the spectroradiometer.

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- 4.5.7.2 Spectroradiometer: The spectroradiometer is the preferred method for measuring color for all types and classes of panels. This method should also be used to calibrate the correction factors for four filter colorimetry. This method shall be invoked when disputes arise from measurement correlation differences between vendor and the procuring activity. The accuracy of the spectroradiometer should be equal to or better than ± 0.005 in x and y for all colors to be tested. After calibration, the spectroradiometer calibration should be validated with either the MEL chromaticity reference filters [see 6.5.1.6.1(d)] or optical filters producing spectral distributions similar to the product under test. The spectral transmittances of the MEL chromaticity reference filters or the similar optical filters should be individually measured with a spectrophotometer or spectroradiometer in a manner similar to that described in 6.5.2.1. Ideally, the spectral transmittances should be measured with a spectrophotometer since an improper use of the spectroradiometer can obscure any measurement problems.
- 4.5.7.3 Color of light (Class 1R and 2R): The panel shall meet the color of light requirements of 3.9 while satisfying the legend color requirements of 3.8.1. The color of light should be measured with a spectroradiometer. An alternative test method may be determined for each of several markings on the panels as follows: The photometer shall be focused on the marking. A reading (R_1) shall be taken. One National Bureau of Standards Type No. 3215 Filter shall then be placed in the optical path between the panel and the photometer. A second reading (R_2) shall then be taken. The ratio of R_2 to R_1 shall be greater than or equal to the value of the IPL Red Limit as determined from the calibration curve of the photometer (see 4.3.3). The IPL Red Limit may also be determined by the method described in MIL-L-25467.
- 4.5.7.4 Measurement disputes: When disputes arise from color measurement correlation differences between vendor and the procuring activity, rejection shall be based upon measurements of the next higher order of accuracy where spectroradiometer (6.5.1.2) measurements take precedence over the four filter photometer/colorimeter method (4.5.7.1).
- 4.5.7.5 Illumination certification: The illumination test facility shall be certified by the qualifying activity as complying with the requirements specified herein.
- 4.5.8 NVIS radiance (Class 1-NVIS Green A): The panels shall meet the NVIS radiance requirements of 3.10 when tested by a spectroradiometer meeting the requirements of Appendix B of MIL-L-85762. A NVIS spotmeter meeting the requirements of 6.5.1.3 and 6.5.1.3.1 may also be used. The measured data points shall include the 3 "brighter" areas or characters as identified by a NVIS device meeting the requirements of 6.5.1.4. The areas of maximum NVIS radiance shall be determined visually with the NVIS device by increasing the panel voltage from zero to rated condition until the first markings visually appear. These markings may have the greatest NVIS radiance values.
- 4.5.8.1 NVIS radiance measurement: Comparison of NVIS radiance measurements by approved illumination test facilities should take into account tolerances inherent in the light measurement technique described in 6.5.2.1. However, the measurement process shall be proven capable of performing NVIS measurements per MIL-L-85762 and the upper limit shall not exceed the limit stated in MIL-L-85762 when stated in terms of 2 significant digits.

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- 4.5.8.2 NVIS radiance certification: The NVIS radiance test facility has been certified by the qualifying activity as complying with the requirements specified herein.
- 4.5.8.3 NVIS radiance measurement disputes: When disputes arise from measurement correlation differences between vendor and the procuring activity, rejection must be based upon measurements of the next higher order of accuracy where the spectroradiometer (6.5.1.2) takes precedence over the NVIS spotmeter (6.5.1.3).
- 4.5.9 Light leakage: Each NVIS panel under test shall be examined in the dark environment in accordance with 3.11 and MIL-L-85762 for light leaks. When observed through a NVIS device meeting the requirements of 6.5.1.4, light leaks may be manifested by a relatively "brighter" than average illuminated character or area. For panels with higher luminance areas (such as areas for knobs), inspection should be performed with a typical knob in place.
- 4.5.10 Gloss: The panel shall meet the Gloss requirements of 3.12 when measured in accordance with the ASTM D523 (60°).
- 4.5.11 Accelerated weathering: The panel shall be exposed for 150 hours to the radiation from a xenon-arc accelerated weathering chamber in accordance with ASTM G26, Type BH, Test Method 1. After exposure, the panel shall be visually compared to a similar unexposed panel. If discoloration of the indicia has occurred, contrast measurements shall be made to determine that the panel meets the specification contrast requirements. Causes for rejection can include, but are not limited to, failure to meet minimum contrast requirements, color of finish requirements, or blistering.
- 4.5.12 Altitude: The plate shall be tested in accordance with Method 105 of MIL-STD-202 for 30 minutes at an altitude of 100,000 feet (30,400 meters) which corresponds to 0.32 inch (8.128 mm) of mercury (Hg).
- 4.5.13 Salt fog test: The panel(s) shall be tested in accordance with Method 101 of MIL-STD-202 for 26 hours.
- 4.5.14 Humidity: The panels shall be subjected to ten cycles in accordance with Procedure III and Figure 507.3-3 of Method 507 of MIL-STD-810.
- 4.5.15 Temperature: The panel shall be placed in the the chamber maintained at -65°C (-85°F) for one hour. It shall then be removed from the cold chamber and placed as rapidly as is practicable (within 3 minutes) in an oven whose temperature is maintained at +85° C (+185° F) for one hour. This procedure shall be repeated four additional times. The panel shall then be cooled naturally and examined. There shall be no evidence of crazing, surface coating deterioration, or discoloration of the marking which reduces the contrast below 9 or 2.5 for black or gray panels, respectively.
- 4.5.15.1 Operation of lamps: Lamps within the panels subjected to temperature tests shall not be operated in ambient temperatures above 71° C.

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- 4.5.16 Solvents and fluids: A felt pad .25 inch (6.35 mm) thick and of 1/2 the area of the panel (Figure 1), shall be saturated with the fluid as required under 3.14. The felt pad shall then be placed on the front face of the panel and held down by a uniformly distributed force of 1.5 pounds (6.7 Newtons) for one minute. At the termination of this time, the felt pad shall be removed from the panel and a clean, lint free, dry cloth shall be used to wipe the face of the panel dry. The panel shall then be examined for evidence of surface coating softening, tackiness, or of the transfer of pigment from the opaque coating to the white markings, or vice versa. Evidence of one or more of these conditions shall be cause for rejection. The gloss of the panel shall not be increased above the maximum value allowed by this specification. The fluids described in paragraph 3.14 shall be used. Upon completion of testing, the panels should be cleaned with lacquer thinner and mild soap and water prior to further photometric or radiometric tests.
- 4.5.17 Surface endurance: The apparatus shall consist of a device which must apply a vertical load of 9.8 Newtons which is achieved by a 1000 gram mass applied to the point of a needle held at an angle of 45 degrees to the horizontal (see Figure 2). The apparatus shall hold the panel in a horizontal position and shall allow the panel to pass horizontally under the needle in a rapid manner. The line scratched on the panel shall lie in the vertical plane containing the axis of the needle. The direction of movement of the panel relative to the needle shall be in the direction of the point. Figure 2 shows the general form of the equipment. The steel needle shall have a right conical point having a vertex angle of 13 to 27 degrees and a spherical tip with a radius of 0.002 to 0.003 inch (0.051 to 0.076 mm). A needle may be used for only one pass unless it is carefully checked to insure that its dimensions are within the limits indicated in Figure 2. See 6.6 for needle sources. The test shall consist of one pass of the needle along the maximum possible unobstructed distance on the front face of the panel. This pass shall include a minimum of one marking character. Except for the point of needle penetration at the beginning and end of the pass, the needle shall not break the surface so as to cause light leakage from the panel or destroy the legibility of the characters.
- 4.5.18 PC board design: The PC board shall meet the requirements of paragraphs 3.4.3, 3.4.3.3, 3.4.3.4, and 3.4.3.5.
- 4.5.19 Radiated emissions (Type VII): Type VII panels that use pulse width modulation techniques for luminance dimming shall meet the requirements of 3.13.6 when tested per MIL-STD-462.
- 4.5.20 Random vibration (Type VII): Type VII panels that use pulse width modulation techniques for luminance dimming shall meet the requirements of 3.13.7 when tested in accordance with Method 214, Test Condition I, Letter A of MIL-STD-202 for 1.5 hours operating in each vibration axis.
- 4.5.21 Sinusoidal vibration (Type VII): Type VII panels that use pulse width modulation techniques for luminance dimming shall meet the sinusoidal vibration requirements of 3.13.8 when tested in accordance with Method 201 of MIL-STD-202 in an operating condition in each vibration axis.
- 4.5.22 Interchangeability: Panels shall meet the requirements of 3.18.
- 4.5.22.1 NVIS radiance interchangeability: Class 1-NVIS Green A panels shall meet the requirements of 3.18.1 when tested in accordance with 4.5.8.

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5. PACKAGING:

5.1 Preservation and packaging:

5.1.1 Level A: The panels shall be preserved in accordance with MIL-P-116, Method III, and packed in accordance with MIL-STD-2073-1. Unit quantities shall be as specified by the procuring activity.

5.1.2 Level C: The panels shall be preserved and packed in accordance with the manufacturer's commercial practice.

5.2 Packing and marking:

5.2.1 Packing: Packing shall be in accordance with Levels A, B, or C or MIL-STD-2073-1 as required by 6.2.c.

5.2.2 Marking: Interior and exterior containers shall be marked in accordance with MIL-STD-129,

6. NOTES:

6.1 Intended use:

The panels covered by this specification are intended for use on control and instrument panels for aircraft, ground, and shipboard applications. Panels for installation in aircraft should conform to MIL-C-6781 whenever possible.

6.2 Ordering data:

Procurement documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) Type and class of panels, and the quantity of each required.
- (c) Level of packaging and packing required.
- (d) Whether IPL red, IPL white, USAF blue white, or NVIS Green A light is required when the lighting units are energized.
- (e) Whether the data item description requirements of MIL-L-85762 are applicable for Class 1-NVIS Green A.

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6.3 Qualification:

With respect to products requiring qualification, awards will be made only for such products as have, prior to the time set forth for opening of bids, been tested and approved for inclusion in the applicable Qualified Products List whether or not such products have actually been so listed by that date. The attention of the qualified manufacturer is called to this requirement and manufacturers are urged to arrange to have the products that they propose to offer to the Federal Government tested for qualification in order that they may be eligible to be awarded contracts or orders for the products covered by this specification. Information pertaining to qualification of products covered by this specification may be obtained from the Commanding Officer, Naval Air Warfare Center, Aircraft Division (Code 440 Mail Stop 60), 6000 East 21st Street, Indianapolis, IN 46219-2189. This location is the former Naval Avionics Center.

6.3.1 Samples: It is to be understood that upon receipt of the Letter of Authorization, Qualification Test Panel (Figure 1) samples will be furnished at no cost to the Government, and that the manufacturer will pay the transportation charges to and from the designated point where tests are to be made. In the case of failure of the sample or samples submitted, consideration will be given to the request of the manufacturer for additional tests only after it has been clearly shown that changes have been made in the product which the Government considers sufficient to warrant additional tests.

6.3.2 Retrofits and modifications (Class 1-NVIS green A): With respect to products requiring retrofits or modifications, awards should be made to manufacturers that have, prior to the time set forth for the opening of bids, had prior products approved for inclusion in the applicable Qualified Products List for NVIS compatible lighting whether or not such products have actually been so listed by that date. Unless otherwise required by the procuring activity, panels undergoing retrofit or modifications for NVIS compatible lighting should meet the performance requirements of this specification.

6.3.3 Repair of Type IV and V panels: Repair of illuminated panels can be accomplished by technicians certified to the requirements of the Miniature-Microminiature (2M) Electronic Assembly Repair Program and NAVAIR Instruction 4790.7A. Guidance to perform these repairs is contained in NAVAIR manual 01-1A-23, Work Package 016. The Lead Technical Activity for this program is the Naval Air Warfare Center, Aircraft Division, Attn: Code 415, Indianapolis, IN. 46219-2189

6.4 Mounting Devices:

Grommets for mounting production panels should be in accordance with MS3498.

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6.5 Illumination test facilities:

The manufacturer must have Naval Air Systems Command certification of his ability to make accurate illumination measurements of the markings of panels covered by this specification. Request for authorization to obtain test facility approval should be addressed to the Naval Air Warfare Center, Aircraft Division, Indianapolis (see 6.3), the activity responsible for qualification. Equipment required and procedures for making the required illumination measurements should be as specified and reside within the facility of the manufacturer (see Table III). It is to be understood that upon receipt of the letter of instruction on procedures for obtaining the test facility approval, samples for comparison and all test equipment required to conduct tests will be provided at no cost to the Government and the manufacturer will pay all transportation costs for test samples required. The following equipment represents the minimum required for a test facility. This facility is required for manufacturers of panels procured under this specification.

6.5.1 Test equipment requirements:

6.5.1.1 Photometer: Each test facility should have photometric equipment capable of measuring luminance and color according to the following specifications:

- (a) Measured spot size - 0.004" to 0.007" (minimum).
- (b) Focus - no less than 4" from the front of the lens.
- (c) Minimum full scale sensitivity 0.1 footlambert.
- (d) Stability: +/- 2% zero and sensitivity combined drift over 8 hour period after 15 minute initial warmup.
- (e) Polarization error: 1% maximum.
- (f) Viewing system: must locate spot being measured with maximum error of 0.002".
- (g) Unit should have digital readout with a resolution of no less than 0.1% of full scale.
- (h) It is desirable that the unit should have a fixed focus lens system with a capability of inserting two 2" square filters into the optical path.

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6.5.1.1 (Continued):

(i) Colorimetric trim:

- (1) Maximum Correction IPL Red Light (3215 Red vs. 2856 Kelvin): +/- 10% of Filter Transmittance.
- (2) 4-Filter Tristimulus Colorimetric Capability - Maximum error for any Blackbody (lamp) Color Temperature: +/- 0.005 x and y from 1800 to 2856 Kelvins when calibrated at 2856K for an ambient temperature excursion of 70° F +/-5° F.

(j) Yearly certification that the photometric equipment meets all of the above parameters is required.

NOTE: A video based image processing and analyzing light meter may be equivalent to the photometer (i.e., meets the requirements of 6.5.1.1) provided a correlation has been established with the photometer. The number of display pixels illuminated by a measurement area equivalent to 6.5.1.1 (a) should equal or exceed twice the Nyquist sampling requirement. Hence at least four detector elements should span any illuminated measurement area in both the horizontal and vertical directions. When the video based light meter is measuring the minimum full scale luminance (6.5.1.1.c), it may be necessary, due to signal-to-noise detector characteristics, to increase the requirement to four times the Nyquist sampling requirement.

6.5.1.2 Spectroradiometer (Class 1-NVIS Green A): The Spectroradiometer should meet the appendix B requirements of MIL-L-85762.

6.5.1.3 NR spotmeter (Class 1-NVIS Green A): Each test facility should have radiometer equipment capable of measuring NVIS radiance according to the following specifications:

- (a) Minimum full scale sensitivity: 1.0×10^{-10} NRa with a minimum spot size of 0.020" and a minimum full scale sensitivity of 0.1 footlambert.
- (b) Stability: +/- 2% zero and sensitivity combined drift over 8 hour period after 15 minute initial warmup.
- (c) Polarization error: 1% maximum.
- (d) Viewing system: must locate spot being measured with maximum error of 0.002".
- (e) Unit should have digital readout with a resolution of no less than 0.1% of full scale.
- (f) Radiometric trim: MIL-L-85762 Class A minus blue filter
- (g) Spectral Response: 380 to 930 nanometers
- (h) Semi-annual certification that the photometric and radiometric portions satisfy 6.5.2.3.

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- 6.5.1.3.1 Correlation: The NVIS spotmeter (6.5.1.3) is an acceptable tester for production provided it has been correlated with a spectroradiometer as discuss in 6.5.2.3 and the manufacturing process is under SPC control as required by 6.5.2.2. Any deviation whatsoever in the manufacturing process (such as a different production lot of paint, filters, lamps, and so on) can immediately nullify the correlation. **FAILURE TO ADHERE TO THIS CORRELATION CAN RESULT IN THE SHIPMENT OF PRODUCT THAT DOES NOT COMPLY TO MIL-L-85762.**
- 6.5.1.4 Night Vision Device (Class 1-NVIS Green A): The NVIS device should meet the luminance gain and resolution of MIL-A-49425. The equivalent background illumination and the signal to noise ratio should be monitored and cannot vary by more than 10% of its initial value. An annual certificate of conformance or a test report should be maintained on file to show compliance with MIL-A-49425.
- 6.5.1.5 Test equipment (electrical):
- 6.5.1.5.1 Voltmeters DC:
- (a) Digital readout (4 full digits minimum).
 - (b) Ranges 0-20, 0-120 (minimum ranges).
 - (c) Accuracy +/- 0.05%
- 6.5.1.5.2 Ammeter:
- (a) Digital readout (4 full digits minimum).
 - (b) Range 0-5 ampere (minimum range).
 - (c) Accuracy +/-0.07%.
- NOTE: Suitable shunts may be used with the above voltmeter providing the shunt and voltmeter combined accuracy meets the ammeter accuracy of +/- 0.07%.
- 6.5.1.5.3 Power supply DC (for panel operation):
- (a) Range: 0-30 volts minimum.
 - (b) Current: 0-5 ampere.
 - (c) Regulation: 0.05% line, maximum ripple 2 mV RMS.
- 6.5.1.5.4 Power supply AC (type VI qualification):
- (a) Range: nominal 0 to 115 volts ac (minimum)
 - (b) Current: nominal 0 to 1 ampere maximum
 - (c) Frequency: 400 +/- 5 Hertz minimum
 - (d) Waveform: sine wave (minimum)
 - (e) Harmonic Distortion: less than -20 dB (relative to fundamental) at full output at 400 Hertz
 - (f) DC Offset: 1 volt maximum

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6.5.1.5.5 Power supply DC (for Luminance Standards):

- (a) Range 0-130 volts (min.).
- (b) Current 0-8 ampere (min.).
- (c) Regulation: 0.02% line.
- (d) Max. Ripple: 10 mV RMS.
- (e) Stability under load: 0.05% per hour

6.5.1.5.6 Power supply DC for Spectral Radiance Standards (Class 1-NVIS Green A):

- (a) Range 0-10 volts (min.).
- (b) Current 0-42 ampere (min.).
- (c) Regulation: 0.02% line.
- (d) Max. Ripple: 10 mV RMS.

6.5.1.5.7 Insulation Resistance Tester:

- (a) 500 volts AC, 60 Hz
- (b) 500 volts DC
- (c) Current: 50 microamperes

6.5.1.5.8 Glossmeter: Meets the requirements of 4.5.10.

6.5.1.6 Test equipment (standards with National Institute of Standards and Technology traceability):

6.5.1.6.1 Photometric:

- (a) Horizontal intensity and color: Three 500-watt or 1000 watt FEL standard incandescent lamps, medium bi-post basing, calibrated for horizontal luminous intensity should be maintained. At least one 500 watt lamp should have a color temperature calibration curve to cover the range of 1800K to 2856K when used with an appropriate diffuser. This lamp and at least one of the luminous intensity standards should be re-calibrated yearly or after 100 hours of use whichever occurs first.
- (b) Opal glass diffuser calibrated for luminous directional transmittance is required.

NOTE:

Standards of luminance and color temperature may be substituted for (a) and (b) above, provided that their accuracy is equivalent to that expected of the system described in paragraphs (a) and (b) above. If the system is self-powered, then the Standard DC power supply described in 6.5.1.5.5 may be deleted. If a self-contained calibration system is provided then the characteristics of 6.5.1.7.2 may also be deleted. Recalibration should be based upon the manufacturer's recommendations for usage but should be performed at least once yearly.

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6.5.1.6.1 (Continued):

- (c) Red filters: At least one Type NBS3215 filter is required.
- (d) Chromaticity reference filters: One set of colored reference filters with data for checking the colorimetric accuracy of the photometer is required. (U.S. Navy Marine Engineering Laboratory, R&D report 91/66 of May 1966.)

6.5.1.6.2 NVIS Radiance (Class 1-NVIS Green A):

- (a) Spectral Radiance Standard: Three Spectral Radiance Ribbon Filament Lamps (30A/T24/13) listed as Standard Reference Materials 39010C (or equivalent). A 2856K white light source with values from 380 to 930 nanometers in 5 nanometer increments at a nominal 1 footlambert. The spectral radiance values should be accurate to within +/- 2%. The color coordinates should be $x = .4476 \pm .001$ and $y = .4075 \pm .003$. The light source should have aperture dimming capability for radiance levels to cover the spectroradiometer linearity verification test of MIL-L-85762.

NOTE:

Standards of spectral radiance may be substituted for (a) above, provided that their accuracy is equivalent to that expected of the system described in paragraph (a) above. Standards of spectral irradiance (such as the NIST standard reference material 39040C 1000 watt quartz halogen type FEL lamps) and a neutral diffuser (calibrated for 0/45 degree reflectance) may be substituted for (a) above provided the qualifying activity has approved the calibration test procedures. The 6.5.1.5.5 power supply would be needed. If the system is self-powered, then the Standard DC power supply described in 6.5.1.5.5 and 6.5.1.5.6 may be deleted. If a self-contained calibration system is provided then the characteristics of 6.5.1.7.2 may also be deleted. Recalibration should be based upon the manufacturer's recommendations for usage but should be performed at least once yearly.

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6.5.1.6.2 (Continued):

(b) NVIS Radiance filters. Absorptive optical filters with spectral transmittances that simulate the Class 1-NVIS Green A spectral distribution for panels. The filter is to transmit the short wavelengths but reject the long wavelengths [i.e., a short wave pass (SWP) filter] with a nominal transition or cut-off wavelength of 600 nanometer at a transmittance level of 5%. The spectral transmittance of this filter should be known within an accuracy of +/- 2% from at least 380 to 930 nanometers in 5 nanometer increments. Spectral transmittance levels are to be measurable to 1.0×10^{-7} within the 600 to 930 nanometer wavelength range so as to generate only the maximum NVIS-A conditions (called out in MIL-L-85762) when combined with the spectral radiant standards. The spectral transmittance values should be measured with a dual beam spectrophotometer or a spectroradiometer (with a dual monochromator) that has a half pass bandwidth of 1.0 nanometers or less. The spectrophotometer or spectroradiometer should be calibrated in accordance with ASTM standards E275 or E925 for transmittance and wavelength. The spectral transmittance values should have NIST traceability. The NIST traceability and accuracy should be demonstrated by comparing the spectrophotometer or spectroradiometer measured spectral transmittances with the NIST certificate spectral transmittances of NIST copper green and cobalt blue spectral transmittance filters (i.e., NIST calibration service 38010C and NIST 38020C) and of NIST neutral density filters (NIST SRM 930D). The spectral transmittance calibration is then transferred to higher absorption neutral density filters by a stepwise combination of the NIST filters and then the calibration transferred to neutral density filters.

6.5.1.7 Dark room facilities:

- 6.5.1.7.1 Dark room: A room designed to provide a dark environment per 4.3 should be provided. The room should be of sufficient size to provide adequate working area for personnel when all of the equipment required for a test facility is contained in the room. The room should be temperature controlled to provide a $70^{\circ} \pm 5^{\circ}$ F ($21.1^{\circ} \pm 2.8^{\circ}$ C) ambient. For class 1-NVIS Green A panels, the dark room should meet the dark environment requirements of MIL-L-85762.
- 6.5.1.7.2 Optics bench: An optics bench for supporting and aligning the photometer, spectroradiometer, photometric and spectroradiometric standards should be provided. The minimum length of the bench should be 9 feet. Accessories for use with the bench should include a means for supporting and positioning of the lamp standards, a means for supporting the opal glass, and adequate light baffles to exclude extraneous light. An integrating sphere with light source, power supply, and voltage/radiance displays may be substituted for the optics bench.
- 6.5.1.7.3 Positioning device: A device for positioning the photometer and panels in a correct relationship for photometric/colorimetric measurements of the panel should be provided. The device should provide for both vertical and horizontal movement of either the photometer or the panel.

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- 6.5.2 Statistical process control (Class 1-NVIS Green A): The manufacturer should implement and use statistical process control (SPC) methods to monitor the process control for NVIS radiance (NR) measurements and the manufacturing process for Class 1-NVIS Green A panels covered by this specification. The measurement process should be shown to be accurate and statistically stable over time (i.e., measuring process is in control). The manufacturing process should be shown to be in statistical control and capable of being less than the maximum level specified in MIL-L-85762. The SPC program should be developed and maintained in accordance with EIA-557 or ASTM STP 15D. Evidence of such compliance should be verified by the qualifying activity as a prerequisite for qualification and retention of qualification. Under special circumstances an alternate process control program may be acceptable subject to approval by the qualifying activity.
- 6.5.2.1 Spectroradiometer measurement process (Class 1-NVIS Green A): The spectroradiometer measurement system should meet the requirements of Appendix B of MIL-L-85762 and should be calibrated and validated with a filter [see 6.5.1.6.2(b)] plus spectral radiance lamp [see 6.5.1.6.2(a)] combination. The validation phase requires an optical filter meeting the requirements of 6.5.1.6.2(b) and maintaining National Institute of Standards and Technology [NIST] traceability. The preferred method is for the spectral transmittance to be measured with a spectrophotometer and not a spectroradiometer. [NOTE: An alternative method is to use a spectroradiometer with less than 1.0 nm HPBW to measure spectral transmittance.] The spectrophotometer or spectroradiometer should be calibrated for wavelength and linearity per ASTM standards E275 and E925. The NIST traceability process includes the use of NIST spectral transmittance filters and neutral density filters in the documented generation of absorptive transfer standards to cover the absorption range down to $1.0 \text{ E-}08$. The NVIS filter is then inserted within the optical path of a NIST traceable spectral radiance standard while accommodating limitations arising from geometric sensitivities. The measured NVIS radiance (NR) value should agree within 10 % of the calculated NR value that is generated by mathematically inserting the filter within the light path of the spectral radiance standard. Ideally, the combination of filter plus spectral radiant source should generate the maximum permissible NVIS radiance levels per MIL-L-85762. Provided the optical filter shows no evidence of fluorescence or optical activity, the spectroradiometer parameters should be optimized to assure validation within 10%. On a periodic basis, the measured value of this filter plus spectral radiance source should be monitored by a statistical process control (SPC) technique. Whenever the validation test fails or the SPC chart shows an abrupt unexplainable discontinuity, the spectroradiometer should be deemed unacceptable for further NR testing until the problem is resolved and the operator reestablishes a valid statistical process control (SPC) measurement process.

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6.5.2.1 (Continued):

The validation phase may also include the generation of a standard light plate that should be repeatedly, routinely and periodically measured over time to monitor the stability, accuracy, and precision of the spectroradiometer measurement process. As a minimum, the standard light plate or the filter plus lamp combination should have a NIST traceable calibrated NVIS radiance value equal to the maximum limit stated in MIL-L-85762. The elapsed time on the standard light plate or the spectral radiant lamp should be less than 100 hours. However, if no change has occurred in the prior values for luminance, color coordinates, or NVIS radiance values, then the standard is acceptable until one or more of these changes do occur. Individual spectroradiometer NVIS radiance values from measuring the standard should be monitored using, for instance, an X and Moving Range (X/movR) control chart. This chart should be used to assess the accuracy, precision, and stability of the measurement system. The accuracy should be assessed by comparing the center line of the X-chart (\bar{X}) to the certified value of the standard; \bar{X} should not differ by more than $\pm 10\%$ of the certified value. The precision should be assessed by monitoring the standard deviation of the NRA measurements, S_m , where $S_m = \text{movR}/1.128$. Whenever the X or movR chart indicates an out-of-control condition, the spectroradiometer operator should ascertain and correct the problem(s) so as to bring the measurement process back into control.

6.5.2.2 Manufacturing process (Class 1-NVIS Green A): The manufacturing process should use SPC techniques on the production class 1-NVIS Green A panels with the three measured NVIS radiance values on a panel as the SPC parameter. The manufacturing process should be monitored using the same type of X and Moving Range control chart as discussed in 6.5.2.1. The acceptance criteria should be whether the manufacturing process is in statistical control and whether or not the upper control limit is maintained under the maximum limit permissible by MIL-L-85762. Whenever the manufacturing process exceeds the upper control limit, the manufacturing process should be examined to ascertain and correct the problem so as to bring the manufacturing process back into control.