

INCH-POUND
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MIL-DTL-7788H  
18 October 2011  
SUPERSEDING  
MIL-DTL-7788G  
15 October 2010

## DETAIL SPECIFICATION

### PANELS, INFORMATION, INTEGRALLY ILLUMINATED

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

#### 1. SCOPE

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

1.2 Classification. The integrally illuminated information panels are of the following classes and types as specified (see 6.2).

1.2.1 Classes. The classes of integrally illuminated information panels are as follows:

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 IPL - White.

Class 1-BW. Panels having the background of the front face of the panel finished with black and the integral illumination of United States Air Force (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 Night Vision Imaging System (NVIS) compatible lighting requirements of MIL-L-85762 is NVIS Green A.

Comments, suggestions, or questions on this document should be addressed to DLA Aviation VEB, 8000 Jefferson Davis Highway, Richmond, VA 23297-5616, or e-mailed to <a href="mailto:STDZNMGT@dla.mil">STDZNMGT@dla.mil</a> . Since contact information can change, you may want to verify the currency of this address information using the ASSIST database at <a href="https://assist.daps.dla.mil/">https://assist.daps.dla.mil/</a> .
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Class 2-R. Panels having the background of the front face of the panel finished with gray and the integral illumination of IPL - Red.

Class 2-W. Panels having the background of the front face of the panel finished with gray and the integral illumination of 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. The type of integrally illuminated information panels are as follows:

Type III - One piece plastic panels. Panels consisting of one sheet of plastic utilizing MIL-DTL-6363/8 lamps in MS25010 light assemblies for illumination.

NOTE: Type III panels should be inactive for new design. Qualification requirements for type III panels should be determined by qualification test results for types IV or V. Type III panels may be updated to types IV or V by the use of adapter plug MIL-DTL-32385/7 (see 6.6).

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

Type V - Printed circuit board panels. Finished panels consisting of one sheet of plastic with MS90451 or MS90452 lamps soldered to a removable printed circuit board recessed within the plastic panel so that the back of the circuit board is under flush to 0.010 inch (0.254 millimeters) over flush of the rear panel surface. 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 3.3.3.4.1).

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

Type VII - Light emitting diode (LED) panels. Finished panels consisting of LEDs soldered to a removable printed circuit board recessed within the plastic panel so that the back of the circuit board is under flush to 0.010 inch (0.254 millimeters) over flush of the rear panel surface.

## 2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3 and 4 of this specification. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of the documents cited in sections 3 and 4 of this specification, whether or not they are listed.

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2.2 Government documents.

2.2.1 Specifications, standards, and handbook. The following specifications, standards, and handbook form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

## FEDERAL SPECIFICATIONS

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

## FEDERAL STANDARDS

FED-STD-595/33538	- Yellow, Flat or Lusterless
FED-STD-595/36231	- Gray, Flat or Lusterless
FED-STD-595/37038	- Miscellaneous, Flat or Lusterless
FED-STD-595/37875	- Miscellaneous, Flat or Lusterless
FED-STD-595/37925	- Miscellaneous, Flat or Lusterless

## COMMERCIAL ITEM DESCRIPTION

A-A-857	- Thinner, Dope and Lacquer (Cellulose Nitrate)
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## DEPARTMENT OF DEFENSE SPECIFICATIONS

MS3338	- Lamp-Incandescent, T-1 Bulb, Based, 28-Volt, Integral Lighting
MIL-PRF-5425	- Plastic Sheet, Acrylic, Heat Resistant
MIL-PRF-6081	- Lubricating Oil, Jet Engine
MIL-DTL-6363	- Lamps, Incandescent, Aircraft Service General Specification for
MIL-DTL-6363/8	- Lamps, Incandescent, Aircraft Service, Single Contact Midget Flanged Base T-1-3/4 Bulb
MIL-PRF-19500	- Semiconductor Devices, General Specification for
MIL-PRF-19500/708	- Displays, Diode, Light Emitting, Solid State, Red, Numeric, and Hexadecimal, with On Board Decoder/Driver Types 4N51, 4N52, 4N53, 4N54 JAN and JANTX
MIL-PRF-22885	- Switches, Push Button, Illuminated, General Specification for
MIL-L-25467	- Lighting, Integral, Red, Aircraft Instrument, General Specification for

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## DEPARTMENT OF DEFENSE SPECIFICATIONS - Continued

MIL-DTL-32385	- Connector, Receptacles, Plugs, Adapter, Used on Electroluminescent, Embedded, and Printed Circuit Board Lamp Lighting Panels
MIL-PRF-38039	- Systems, Illuminated, Warning, Caution, and Advisory, General Specification for
MIL-I-46058	- Insulating Compound, Electrical (for Coating Printed Circuit Assemblies)
MIL-PRF-83282	- Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, Metric, NATO Code Number H-537
MIL-L-85762	- Lighting, Aircraft, Interior, Night Vision Imaging System (NVIS) Compatible
MS90451	- Lamp, Incandescent, T-1 Bulb, Short, Integral Lighting
MS90452	- Lamp, Incandescent, T-3/4 Bulb, Integral Lighting

## DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-130	- Identification Marking of U.S. Military Property
MIL-STD-202	- Electronic and Electrical Component Parts
MIL-STD-411	- Aircrew Station Alerting Systems
MIL-STD-461	- Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-810	- Environmental Engineering Considerations and Laboratory Tests
MIL-STD-31000	- Technical Data Packages

## DEPARTMENT OF DEFENSE HANDBOOK

MIL-HDBK-454	- General Guidelines for Electronic Equipment
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(Copies of these documents are available online at <https://assist.daps.dla.mil/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.2.2 Other government document. The following other government document forms a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

## OTHER GOVERNMENT DOCUMENT

SD-6	- Provisions Governing Qualification
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(Copies of this document are available online at <https://assist.daps.dla.mil/> or from the Standardization Document Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094.)

2.3 Non-government publications. The following documents form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those cited in the solicitation or contract.

### AEROSPACE INDUSTRIES ASSOCIATION (AIA)

NASM 3498 - Screw Assembly, Panel

(Copies of this document are available online at <http://www.aia-aerospace.org/> or from Aerospace Industries Association, 1000 Wilson Blvd, Suite 1700, Arlington, VA 22209-3928.)

### AMERICAN SOCIETY FOR QUALITY (ASQ)

ASQ Z1.4 - Sampling Procedures and Tables for Inspection by Attributes

(Copies of this document are available online at <http://www.asq.org> or from the American Society for Quality, 600 North Plankinton Avenue, Milwaukee, WI 53023.)

### ASTM INTERNATIONAL

ASTM D523 - Standard Test Method for Specular Gloss  
ASTM D1729 - Standard Practice for Visual Appraisal of Colors and Color Differences of Diffusely-Illuminated Opaque Materials  
ASTM G155 - Standard Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

(Copies of these documents are available online at <http://www.astm.org> or from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.)

### IPC - ASSOCIATION CONNECTING ELECTRONIC INDUSTRIES

IPC J-STD-001 - Requirements for Soldered Electrical and Electronic Assemblies  
IPC-2221 - Generic Standard on Printed Board Design  
IPC-4101 - Specification for Base Materials for Rigid and Multilayer Printed Boards

(Copies of these documents are available from <http://www.ipc.org> or from IPC - Association Connecting Electronic Industries, 3000 Lakeside Drive, Suite 3095, Bannockburn, IL 60015-1219.)

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## SAE INTERNATIONAL

SAE AS18012	- Markings for Aircrew Station Displays Design and Configuration of
SAE AS25050	- Colors, Aeronautical Lights and Lighting Equipment, General Requirements for

(Copies of these documents are available online at <http://www.sae.org> or from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001.)

2.4 Order of precedence. Unless otherwise noted herein or in the contract, 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 (QPL) at the time of award of contract (see 4.1 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 listed as group I in table VI and described in section 4 shall apply to this panel. In addition, test capabilities described in Appendix A must be available for performance of qualification and conformance tests. Note: production panels involve a variety of shapes and sizes and will not necessarily resemble the qualification panel shown in figure 1. Requalification shall consist of the same tests described for qualification.

3.1.1 Maintenance of qualification. At specified intervals determined by the qualifying activity, the manufacturer must be able to demonstrate that the company still has the capabilities and facilities necessary to produce the QPL items in accordance with this specification and in accordance with the provisions governing qualification specified in SD-6. The procuring activity or qualifying activity 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 maintained within the past two years for at least a type IV, a type V, and a minimum of two appropriate dissimilar classes (excluding NVIS). 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 LEDs 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 LEDs and different internal circuit design on the basis of prior qualification for types IV or V or for other classes.

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Qualification by similarity for all classes in types IV, V, VI, and VII:

- 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 (red, white, blue-white, and NVIS Green A) as well as both background colors (black and gray) will qualify by similarity for all classes within that type. For example: 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 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.

3.1.3 Approval of class 1-NVIS Green A panels. When required by the procuring activity, class 1-NVIS Green A panels shall meet the first article requirements of MIL-L-85762. 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 Design. Panel design shall meet the classification requirements of 1.2.

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

3.3.1 Materials and parts. Except for surface finishing, electrical circuitry, connectors, and sealants, the panels shall be made of transparent plastic in accordance with MIL-PRF-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 warping due to environmental stresses. Panels may be fabricated from other materials, subject to prior approval by the procuring activity.

3.3.2 Panel thickness. The finished panels, excluding grommet and power connectors, shall be  $0.240 \pm 0.023$  inch ( $6.096 \pm 0.584$  millimeters (mm)) thick. The type V and VII panels shall have the printed circuit board recessed within the plastic panel so that the back of the circuit board is under flush to 0.010 inch (0.254 mm) over flush of the panel rear surface.

3.3.3 Light source. The light source may be incandescent, LED, or EL. The incandescent lamps shall meet the requirements of MIL-DTL-6363 (including vibration) and one of the following appropriate drawings: MS90451 or MS90452. LEDs shall be either hermetic or plastic encapsulated packages, with leads for either through-hole or surface mount assembly. The LEDs should be selected for light output and color in accordance with either MIL-PRF-19500, MIL-PRF-19500/708, or as detailed in the LED specification drawing.

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3.3.3.1 Lamp embedment. Panels are constructed with either incandescent, LED, or EL 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 mm) of plastic between the lamps and the front face of the panel. EL lamps shall be contained within and recessed 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 embedded light sources and associated circuitry shall be recessed from the rear surface of the panel and covered with a minimum of 0.020 inch (0.508 mm) 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.

3.3.3.2 Lamp quantity. Types 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 3.7.5. Unless otherwise specified by the procuring activity:

- a. Type IV panels are preferably restricted to not more than ten lamps. If more than ten lamps are required, then a type V panel design should be used.
- b. Type VI panels may employ one or more EL lamps.
- c. Type VII panels should employ at least two LED assemblies (see 3.3.3.4.2).

3.3.3.3 Printed circuit board types V and VII. As a minimum, circuit boards shall conform to type 21 per IPC-4101. 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 mm minimum) rather than narrow ribbons of copper conductor. The conductor pattern should have a minimum clearance of 0.050 inch (1.270 mm) 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 screws (2-56 preferred) 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.

3.3.3.3.1 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 NVIS devices or exceeds the NVIS radiance (NR) levels of MIL-L-85762. In addition, a sufficient number of screws (2-56 preferred) 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.

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3.3.3.4 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 6.9.2 and 6.10), except type V and type VII shall be in accordance with IPC-2221. All conductor circuit material shall be soldered to the lamp leads and the electrical connector. Soldering shall be in accordance with IPC-J-STD-001. Guidance regarding safe electrical circuit design is given in MIL-HDBK-454, guideline 1. The connector center pin shall be the positive terminal in accordance with MIL-DTL-32385. The type and number of lamps used in type IV, V, 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.

3.3.3.4.1 Incandescent lamp circuit. Unless otherwise specified 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 or T1 3/4 front relampable light assemblies are not recommended due to the proliferation of nonstandard lamp assemblies, short lamp life, and 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. Unless otherwise specified, embedding of unbased 28 volt lamps is not acceptable.

3.3.3.4.2 LED circuit. LEDs may be electrically connected in parallel or in series/parallel combinations provided compensation is made for the polarity and direct current characteristics of LEDs (for instance, an LED may be defined as consisting of two LEDs in electrical parallel where one LED is forward biased and one is reversed biased; that is, the cathode of the first LED is connected to the anode of the second LED, and the anode of the first LED is connected to the cathode of the second LED). Each individual LED connected in parallel and each string of LEDs connected in series/parallel combination shall have appropriate current limiting. Panels with LEDs connected only in parallel shall be operated from a 5-volt power source. Panels with LEDs connected in series/parallel combinations may be operated from either a 5-volt or a 28-volt power source, as determined by the internal LED circuit configuration. If transient overvoltage and/or reverse voltage protection is required, the protection circuit shall be included in the internal circuit within the panel.

3.3.3.4.3 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.

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3.3.3.5 Electrical connectors. Connectors of the MS90335 type (part number) as used in qualification panels and production panels as defined in this specification shall meet all dimensional and other requirements of MIL-DTL-32385. For those panels utilizing a printed circuit board (PCB) construction, the typical connector used is part MS90335-8 and for those panels utilizing a potted construction, the typical connector is part MS90335-7. Type IV and VI panels utilizing one electrical circuit shall use the MS90335 type plug potted assembly and the collar shall extend  $0.140 \pm 0.010$  inch ( $3.556 \pm 0.254$  mm) from the rear surface of the panel. Type V and VII panels utilizing one electrical circuit shall use the MS90335 type PCB mounted plug assembly and the collar shall extend  $0.135 \pm 0.010$  inch ( $3.429 \pm 0.254$  mm) from the rear surface of the panel. The MS90335 type PCB mounted 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 circuit of the panel is disconnected from the power source by removal of the panel, center pin recessed, MS90335 type connector. The connector mounting provisions shall not protrude beyond the rear surface of the panel or circuit board.

3.3.3.5.1 Connector location. A white, non-illuminated cross (+) approximately 0.08 inch (2.032 mm) by 0.08 inch (2.032 mm) shall be centered and located on the front surface of the panel approximately above the electrical connector (see figure 1). The centering and location of the connector cross 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.

3.3.4 Rated voltage (test purposes). The rated operating voltage, as measured at the panel connector, for type VI panels shall be  $115 \pm 2$  volts alternating current (VAC) at  $400 \pm 5$  Hertz (Hz). The rated operating voltage for type IV, V, and VII panels shall be as shown in table I.

TABLE I. Operating voltage for types IV, V, and VII panels.

Class	Rated operating voltage for types IV, V, and VII panels
1-R, 2-R	$5.0 \pm 0.05$
1-W, 2-W	$5.0 \pm 0.05$
1-BW, 2-BW	$4.5 \pm 0.05$
1-NVIS Green A	$5.0 \pm 0.05$

The luminance requirements for 28 volt lamps shall be met at  $28.0 \pm 0.1$  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 and LED circuits designed for AC applications.

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3.3.5 Mounting. The panels shall be designed to permit removal without disturbing components thereof, except for knobs, lamp holders and hold-down fasteners.

3.3.5.1 Grommets. Grommets of the NASM 3498 type as used for production panels as defined in this specification shall meet all dimensional and other requirements of NASM 3498.

3.3.5.2 Fasteners. Unless otherwise specified, fasteners shall consist of 6-32 machine screws. A fastener for each 8 square inches ( $\text{in}^2$ ) (5161.3 square millimeters ( $\text{mm}^2$ )) of surface area shall be provided. No fewer than two screws shall be used. The panel shall have provisions, such as NASM 3498 grommets, to prevent it from being crushed by the screws. Fasteners shall be symmetrically spaced to minimize panel warping that may affect the operation of the controls.

3.3.5.3 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.

3.4 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 specification drawings (including current as required) and as specified by the procuring activity.

3.5 Insulation resistance, types IV, V, VI, and VII. The panel leakage current measured in accordance with 4.4.4 shall not exceed 50 microamperes ( $\mu\text{A}$ ).

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

3.6.1 Surface coating. Except for the markings, those areas required for lighting functions, and the circuit board in type V and VII panels, all viewable surfaces in the mounted condition of each panel shall be opaque and shall be the color specified in 3.6.2.1 for the background of the front of the panel.

3.6.2 Background colors. Background colors shall be in accordance with 3.6.2.1. 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 external finish of any lamp holder and attaching hardware shall correspond to the background color of the panel.

3.6.2.1 Color of finishes. Finishes shall conform to colors shown in table II when examined under "cool white" fluorescent illumination (International Commission on Illumination (CIE) illuminant F2).

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TABLE II. Panel finish colors.

Color	Color number
Black	FED-STD-595/37038
Gray	FED-STD-595/36231
White	FED-STD-595/37875 or FED-STD-595/37925 <sup>1</sup>
Yellow	FED-STD-595/33538

<sup>1</sup> Only FED-STD-595/37925 white is permissible for class 1-NVIS Green A and it shall be untinted. Tinting shall not be used to achieve a match with FED-STD-595/37925. (FED-STD-595/37875 often has tinting pigments introduced for color matching that are incompatible with MIL-L-85762.)

3.6.2.2 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.

3.6.2.3. Immediate action stripes. Immediate action striping is used to identify controls that may require immediate access. The panel marking consists of a yellow striping pattern surrounding the control for fast identification. There are two standard patterns, NVIS compatible and non-NVIS compatible. The yellow stripe shall be non-illuminated for the NVIS compatible configuration and trans-illuminated for the non-NVIS configuration.

3.6.2.3.1 Immediate action striping – NVIS compatible. The immediate action striping on NVIS compatible panels shall follow a recurring yellow/black/white/black/yellow pattern with only the white stripe trans-illuminated. The striping pattern should begin and end with a yellow stripe if possible and the stripes shall be applied at a 45 degree angle to the vertical, rotated clockwise. As shown in figure 2, the black stripes shall have a width of 0.062 to 0.25 inch, and the yellow and white stripes shall be three times the width of the black stripes. Striping colors shall be yellow in accordance with FED-STD-595/33538; black in accordance with FED-STD-595/37038; and white in accordance with FED-STD-595/37925.

3.6.2.3.2 Immediate action striping – Non-NVIS compatible. The immediate action striping on non-NVIS compatible panels shall follow a recurring yellow/black/yellow pattern with the center 0.125 stroke width of the yellow stripe trans-illuminated. The striping pattern should begin and end with a yellow stripe if possible and the stripes shall be applied at a 45 degree angle to the vertical, rotated clockwise. As shown in figure 3, the black stripes shall have a width of 0.062 to 0.25 inch, and the yellow shall be three times the width of the black stripes. Striping colors shall be yellow in accordance with FED-STD-595/33538 and black in accordance with FED-STD-595/37038.

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3.7 Legends and marking. The legends and markings on each panel shall be finished with white conforming to FED-STD-595/37875 or /37925 (for NVIS compatible panels). The font, or typeface, shall conform to SAE AS18012, or other font approved by the procuring activity. 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.

3.7.1 Legend color. The lettering, numbering, and (except for yellow immediate action stripes) the marking of the plastic lighting panel shall be finished with white, FED-STD-595/37875 or /37925 (for class 1-NVIS Green A) when examined under "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 black, yellow, black, and white stripes where lighting shall transilluminate only the white stripes (see 3.6.2.3.1).

3.7.2 Contrast. The daylight contrast between markings, legends, indicia, and the background on the panel shall be determined with the panel lighting system inoperative and in accordance with 4.4.5. 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.

3.7.3 Luminance of markings. Unless otherwise specified, the luminance of all markings on the panels (and associated knobs or dials if supplied by the manufacturer) when illuminated by the integral lighting system at the rated voltage (see 3.3.4) only, shall be as shown in table III.

TABLE III. Luminance of markings.

Panel type	Class	Luminance of marking (foot-lambert)	Luminance of marking (candelas/square meter)
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

3.7.3.1 Luminance (type III). Each type III panel shall meet the specified illumination requirements with MIL-DTL-6363/8 lamps operating at 0.34 ±0.02 spherical candelas installed in each lamp holder.

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3.7.4 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.

3.7.5 Luminance maintenance. In the event of a lamp failure, the luminance of any marking depending on the incandescent or LED light source and the associated circuitry (see 3.3.3.4 and subparagraphs) shall not be reduced below the minimum listed at the rated voltage (see 3.3.4) as shown in table IV.

TABLE IV. Minimum luminance of markings.

Panel type	Class	Luminance of marking (foot-lambert)	Luminance of marking (candelas/square meter)
IV, V and VII	1-R and 2-R	0.15	0.51
	1-W and 2-W	0.50	1.7
	1-BW and 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 or dials if supplied by the manufacturer) 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.

3.7.5.1 Failed lamp, type IV, V and VII panels submitted for qualification inspection (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 MIL-DTL-32385 connector. An alternate approach is to use a switch block with dual in-line package (DIP) switches that permit each lamp to be individually switched on/off.

3.7.5.2 Type V front relampable. When MS3338 based lamps are used with hardware permitting replacement of lamps from the front face of the panel, the luminance requirements of 3.7.5 do not apply.

3.8 Color of light. The light transmitted through the panel marks, legends and indicia and all elements illuminated by the panel shall meet the following requirements (see table V) when the lighting system is operated at a rated voltage (see 3.3.4) as measured at the panel connector (except that NVIS Green A shall be at the necessary voltage to produce 0.1 foot-lambert (0.3 candelas/square meter (cd/m<sup>2</sup>)):

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TABLE V. Color of light.

Class	Standard	Chromaticity requirements
1-R and 2-R	SAE AS25050	IPL Red, type I(f)
1-W and 2-W	SAE AS25050	IPL White, type I(g)
1-BW and 2-BW	SAE AS25050	Blue-filtered white, type I(h)
1-NVIS Green A	MIL-L-85762	NVIS Green A at 0.1 foot-lambert

The light transmitted through the white portion of class 1-NVIS Green A immediate action stripes (see 3.6.2.3) shall also meet the above chromaticity requirements, but the yellow portion shall not be illuminated.

3.9 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 3.3.4) as measured at the panel connector and when scaled for 0.1 foot-lambert ( $0.3 \text{ cd/m}^2$ ). NVIS radiance shall be measured in accordance with 4.4.8.

3.10 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 (see 4.4.9). Stray light leaks are permissible around grommets (mounting hardware), electrical connectors and fasteners. Stray light leaks are filtered light leaks that meet the NVIS lighting compatibility requirements of MIL-L-85762. NVIS light leaks are unfiltered light leaks that do not meet the NVIS lighting compatibility requirements of MIL-L-85762.

3.11 Gloss. The gloss of the background of the panel shall not exceed 5 units when measured in accordance with 4.4.10.

3.12 Environmental tests. The panels shall maintain the requirements for circuit continuity (see 3.4), insulation resistance (see 3.5), contrast (see 3.7.2), luminance (see 3.7.3), color (see 3.8), NVIS radiance (see 3.9), light leakage (see 3.10), and gloss (see 3.11) before and after exposure to the environmental tests. These environmental tests are performed without power supplied to the panel.

3.12.1 Accelerated weathering. The panels shall be subjected to an accelerated weathering test (see 4.4.11) for 150 hours in an accelerated weather chamber with humidity control in accordance with exposure cycle 1 of ASTM G155, using an apparatus capable of automatic programming of temperatures and cycles. The exposure apparatus shall have automatic humidity control.

3.12.2 Altitude. The panels shall be subjected to the altitude test of 4.4.12 when tested in accordance with method 105 of MIL-STD-202 for 30 minutes at an altitude of 100,000 feet (30,400 meters), corresponding to 0.32 inch (8.128 mm) of mercury (Hg).

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3.12.3 Salt fog. The panels shall be subjected to the salt fog test of 4.4.13 when tested in accordance with method 101 of MIL-STD-202 for 26 hours.

3.12.4 Humidity. The panels shall be subjected to the humidity test of 4.4.14 for ten cycles in accordance with procedure II of method 507 of MIL-STD-810.

3.12.5 Temperature. The panels shall be capable of withstanding five cycles of temperature shock where each cycle consists of a 1 hour soak time at -65 °C (-85 °F), a maximum 3 minute transition between -65 °C (-85 °F) and +85 °C (+185 °F), and a 1 hour soak time at +85 °C (+185 °F) when performed in accordance with 4.4.15.

3.12.6 Radiated emissions (type VII). Type VII panels that incorporate pulse width modulation techniques for luminance dimming shall meet the applicable radiated emissions requirements of RE101 and RE102 of MIL-STD-461 when tested in accordance with 4.4.18.

3.12.7 Random vibration (type VII). Type VII panels that incorporate pulse width modulation techniques for luminance dimming shall meet the random vibration requirements of 4.4.19. There shall be no visually perceptible change or degradation in luminance, color, or NVIS radiance.

3.12.8 Sinusoidal vibration (type VII). Type VII panels that incorporate pulse width modulation techniques for luminance dimming shall meet the sinusoidal vibration requirements of 4.4.20. There shall be no visually perceptible change or degradation in luminance, color, or NVIS radiance.

3.13 Solvents and fluids. The surface finish of the panel shall not exhibit degradation when subjected to the solvents and fluids test of 4.4.16 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 A-A-857; engine oil of grade 1010 meeting the requirements of MIL-PRF-6081; grease cleaning compound meeting the requirements of P-C-444; and hydraulic fluid meeting the requirements of MIL-PRF-83282. Upon test completion, the panels should be cleaned with lacquer thinner and mild soap and water.

3.14 Surface endurance. The panel shall be capable of withstanding the surface endurance test of 4.4.17 after exposure to the environmental tests.

3.15 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 (see 3.6.2 and subparagraphs), legends and markings (see 3.7 and subparagraphs), contrast (see 3.7.2), luminance (see 3.7.3), luminance maintenance (see 3.7.5), color coordinates (see 3.8), and when applicable, NVIS radiance (see 3.9) and light leakage (see 3.10). These requirements are not applicable for conventional pushbutton switches meeting the requirements of MIL-PRF-22885 or MIL-PRF-38039. The design, construction, and dimensional requirements of the source control drawings may take precedence over 3.2, 3.3, and subparagraphs.

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3.16 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 order given or all located in one area of the panel:

- a. Panel manufacturer's Commercial and Government Entity (CAGE) code.
- b. Panel manufacturer's or design activity part number (as applicable).
- c. Design activity's CAGE code (if different from manufacturer's CAGE).
- d. Design activity part number (as applicable).
- e. National Stock Number (NSN).
- f. Panel manufacturer's name and process designation.
- g. 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.

3.17 Interchangeability. All parts having the same panel manufacturer's part number identification shall be functionally and dimensionally interchangeable. The drawing number requirements of MIL-STD-31000 shall govern changes in the manufacturer's part number.

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

3.19 Recycled, recovered, or environmentally preferable materials. Recycled, recovered, or environmentally preferable materials should be used to the maximum extent possible, provided that the material meets or exceeds the operational and maintenance requirements, and promotes economically advantageous life cycle costs.

#### 4. VERIFICATION

4.1 Classification of inspections. The inspection and testing of integrally illuminated information panels shall be classified as follows:

a. Qualification tests. Qualification tests are group I tests (see table VI) as performed on sample panels made in accordance with figure 1 of this specification and submitted to the procuring or qualifying activity for approval of a manufacturer's processes (see 4.1.1).

b. Conformance tests. Conformance tests are group II tests (see table VI) 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.

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TABLE VI. Qualification and conformance testing.

Inspections		Requirement paragraph	Test paragraph	Test	
				Group I qualification	Group II conformance
Examination of product	Visual defect	3.7.1	4.4.1	X	100%
	Finish color	3.6		X	100%
	Dimensional	3.3.2		X	Sample
Circuit continuity		3.4	4.4.3	X	100%
Insulation resistance		3.5	4.4.4	X	Sample
Photometric baseline tests	Contrast	3.7.2	4.4.5	X	Sample
	Brightness	3.7.3	4.4.6	X	Sample
	Color of light	3.8	4.4.7	X	Sample
	NVIS radiance	3.9	4.4.8	X	* 100%
	Light leakage	3.10	4.4.9	X	** 100%
	Gloss	3.11	4.4.10	X	Sample
Environmentals	Accelerated weather	3.12.1	4.4.11	X	
	Altitude	3.12.2	4.4.12	X	
	Salt fog	3.12.3	4.4.13	X	
	Humidity	3.12.4	4.4.14	X	
	Temperature	3.12.5	4.4.15	X	
	Radiated emissions	3.12.6	4.4.18	X	
	Random vibration	3.12.7	4.4.19	X	
	Sine vibration	3.12.8	4.4.20	X	
Post-environmental	Contrast	3.7.2	4.4.5	X	
	Brightness	3.7.3	4.4.6	X	
	Color of light	3.8	4.4.7	X	
	NVIS radiance	3.9	4.4.8	X	
	Light leakage	3.10	4.4.9	X	
	Gloss	3.11	4.4.10	X	
	Circuit continuity	3.4	4.4.3	X	
	Insulation resistance	3.5	4.4.4	X	
Failed lamp		3.7.5	4.4.6.1	X	
Surface endurance		3.14	4.4.17	X	
Solvents and fluids	Lacquer thinner			X	
	Engine oil			X	
	Hydraulic fluid	3.13	4.4.16	X	
	Grease cleaner			X	

\* 100% visual examination with the worst case subjected to 4.4.8.

\*\* 100% visual examination.

4.1.1 Qualification testing. A sample for qualification testing shall consist of six identical panels for each type, as determined by the qualifying activity, 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 3.7.5.1. Multiple processes may require a reduced number of samples when authorized by the procuring or qualifying activity.

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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.

4.1.1.1 Electrical connector part MS90335 qualification testing. Certificates of conformance shall be furnished with the test panels submitted for qualification inspection to show that the electrical connectors are in compliance with MIL-DTL-32385 and that the electrical connectors were manufactured by a qualified products list manufacturer.

4.1.1.2 Lamp certification. A certificate of conformance or a test report shall be furnished with the test panels submitted for qualification inspection to show compliance with MIL-DTL-6363 and the appropriate lamp MS drawings. For LEDs, the specification drawings and certification of any reliability testing shall be provided for the types of LEDs used.

4.1.1.3 Tests. Qualification tests shall consist of all of the tests in table VI and described under 4.3, except "Arrangement of Controls" (see 4.4.2), and shall be performed in the order shown in table VII. Qualification approval shall extend for a two year period, except that requalification may be required at any time the manufacturer undergoes a change in key personnel, moves their manufacturing plant to a new address, undergoes a major process change, or undergoes management changes at the manufacturing plant.

TABLE VII. Test sequence.

Test	Sample no.⇒	1	2	3	4	5	6
1	Examination of product (See 4.4.1)	X	X	X	X	X	X
2	Circuit continuity (See 4.4.3)	X	X	X	X	X	X
3	Insulation resistance (See 4.4.4)	X	X	X	X	X	
4	Contrast (See 4.4.5)	X	X	X	X	X	X
5	Luminance (See 4.4.6)	X	X	X	X	X	X
6	Luminance maintenance (See 4.4.6.1)						X
7	Color of light (See 4.4.7)	X	X	X	X	X	X
8	Class 1-NVIS radiance (See 4.4.8)	X	X	X	X	X	X
9	Class 1-NVIS leakage (See 4.4.9)	X	X	X	X	X	X
10	Gloss (See 4.4.10)	X	X	X	X	X	X
11	Accelerated weathering (See 4.4.11)	X	X	X	X		
12	Altitude (See 4.4.12)	X	X				
13	Salt fog (See 4.4.13)			X			
14	Humidity (See 4.4.14)	X	X		X		
15	Temperature (See 4.4.15)	X		X			
16	Type VII radiated emissions (See 4.4.18)	X		X			
17	Type VII random vibration (See 4.4.19)	X		X			
18	Type VII sinusoidal vibration (See 4.4.20)	X		X			

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TABLE VII. Test sequence - Continued.

Test	Sample no. ⇨	1	2	3	4	5	6
19	Contrast (See 4.4.5)	X	X	X	X		
20	Luminance (See 4.4.6)	X	X	X	X		
21	Color of light (See 4.4.7)	X	X	X	X		
22	NVIS radiance (See 4.4.8)	X	X	X	X		
23	NVIS radiance leakage (See 4.4.9)	X	X	X	X		
24	Gloss (See 4.4.10)	X	X	X	X		
25	Circuit continuity (See 4.4.3)	X	X	X	X		
26	Insulation resistance (See 4.4.4)	X	X	X	X		
27	Lacquer thinner (See 4.4.16)	X					
28	Engine oil (See 4.4.16)		X				
29	Hydraulic fluid (See 4.4.16)			X			
30	Grease cleaner (See 4.4.16)				X		
31	Surface endurance (See 4.4.17)	X	X	X	X		

4.2 Test conditions.

4.2.1 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 mm) Hg at a temperature of 21 °C ±3 °C (69.8 °F ±5.4 °F), and a relative humidity of 80 percent or less.

4.2.2 Lighting conditions. Luminance and chromaticity measurements shall be made in a dark room where the ambient spectral radiant energy over the spectral range of 380 to 780 nanometers is either not measurable (equivalent to system noise) or no greater than 0.1 percent of the value of spectral radiant energy from the test sample being measured. 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 percent of the value of spectral radiant energy from the test sample being measured.

4.3 Conformance inspection. The contractor shall perform all of the group II tests as specified in table VI. All quality related inspection and test records shall be maintained for a minimum period of 7 years from the date of manufacture. These quality records shall be housed at the manufacturing site and shall be available for review upon request.

4.3.1 Conformance tests. Each integrally illuminated information panel or panel sample submitted for acceptance shall be subjected to the group II conformance tests listed in table VI. These tests need not be performed in the order listed. These tests shall determine compliance with the requirements of design, construction, workmanship, and operational accuracy. If a panel or panel sample fails any of the group II tests listed in table VI, the production lot shall be rejected.

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4.3.1.1 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.

4.3.1.2 Resubmitted inspection lot. For inspections and tests using representative sample panels, ASQ Z1.4 shall apply except that a resubmitted inspection lot shall be inspected using an increased sample size. An increased sample size represented by the next higher sample size code letter shall be selected. Before resubmission, a detailed description of the cause for the previous rejection and the actions taken to correct the defects found in the inspection lot shall be documented by the contractor. The detailed description shall be available for review by the procuring activity when requested.

4.3.2 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 corrected.

#### 4.4 Test methods.

4.4.1 Examination of product. Each sample panel submitted shall be examined to determine conformance with applicable drawings and the requirements of section 3. Workmanship shall be examined thoroughly to insure compliance with the appropriate requirements with respect to materials, including 3.2, 3.3.1, 3.3.3, markings (3.7), outline dimensions, connectors, including 3.3.3.5.1, finish (3.6), display, and assembly using appropriate measuring tools.

4.4.1.1 Color of finishes. Finishes shall meet 3.6.2.1 when tested in accordance with ASTM D1729.

4.4.2 Arrangement of controls. The panel shall be examined to determine that the controls and their arrangements are in accordance with the applicable drawings.

4.4.3 Circuit continuity (types IV and V). The panel shall meet the requirements of the appropriate MS drawing as required by 3.3.3 and 3.4.

4.4.4 Insulation resistance (types IV, V, VI and VII). The panel shall meet the requirements of 3.5. The panel shall be fastened to a conductive metal backplate having minimum dimensions equal to those of the panel. The back plate shall have clearance holes for all electrical connectors. A potential of 500 VAC, 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 3.5.

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4.4.5 Contrast. The measuring apparatus shall consist of a suitable photometer or spectrometer and light source (see figure 4) meeting the characteristics described in the Appendix A. The front of the panel shall be perpendicular to the optical axis of the photometer or spectrometer. The panel shall not be energized. Illumination of the panel shall be provided by a uniform diffuse artificial illumination adjusted for approximately 50 foot-candles. The luminance of the markings and of the background adjacent to these indicia shall be measured. The contrast shall be calculated using the formula in 3.7.2 and shall meet the requirements of 3.7.2.

4.4.6 Luminance test method. The panel shall be tested for compliance with 3.7.3 and 3.7.5 with a photometer or spectrometer that meets the characteristics described in Appendix A. 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 3.3.3 and on the applicable drawing. Tests shall be conducted in a dark room meeting the requirements of 4.2 (see Appendix A). 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 3.7.3 and 3.7.5. 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 3.3.4 and photometrically measure the luminance of the brightest and dimmest markings, as determined by the above visual inspection, using the measurement points of figure 5 as a guide. The measured spot sizes shall be no less than 50 percent and no greater than 80 percent of the character stroke width. The luminance values to be reported shall be an average of three measurements for the minimum and maximum luminance measured. Any single measurement greater than 20 percent above or below the 3.7.3 or 3.7.5 requirements shall constitute failure.

4.4.6.1 Failed lamp - type IV, V, and VII panels submitted for qualification tests (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 3.7.5.1. While a lamp is de-energized, the luminance of markings depending partially on the de-energized lamp for illumination shall be measured and shall meet the requirements of 3.7.5.

4.4.6.2 Luminance measurements (all types). Comparison of photometric luminance measurements 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 in table VIII below, then the panels shall be accepted, provided the illumination test measures the luminance as being within the limits shown under column P in table VIII. In any event, the total spread in the luminance data shall not exceed the tolerances specified in 3.7.3.

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TABLE VIII. Luminance measurements.

Color of light (classes)	M Foot-lamberts	P Foot-lamberts	M cd/m <sup>2</sup>	P cd/m <sup>2</sup>
1-R and 2-R	0.5 to 1.5	0.47 to 1.58	1.7 to 5.1	1.61 to 5.41
1-BW and 2-BW	0.5 to 1.5	0.47 to 1.58	1.7 to 5.1	1.61 to 5.41
1-W and 2-W	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

4.4.7 Color of light. The panel shall meet the color of light requirements of 3.8 while satisfying the legend color requirements of 3.7.1. The color of the light (except class 1-R and 2-R) emitted by the panels shall be measured in accordance with MIL-L-85762. The panels may be measured by either four-filter colorimetry or by a spectroradio-metric 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 selection of those areas that appear to differ from the average color of the panel.

4.4.7.1 Four-filter colorimetry. The photometer should be certified as meeting the requirements as described in the Appendix A and shall be calibrated using similar spectral distributions as the class of panels being measured. Four-filter colorimetry is the preferred method for types IV, V, VI, and VII, all classes (except class 1-R and 2-R). The photometer used for this test shall be certified to accuracies within  $\pm 0.005$  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 ( $C_1$  and  $C_2$  see paragraphs 4.4.7.1.1 and 4.4.7.1.2) specific for that panel. This enhancement is required whenever light emitted by LEDs, EL lamps, 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 change in correction factors required to achieve correlation with the spectroradiometer.

4.4.7.1.1 Compensation to color accuracy. The correction factor or "calibration constants"  $C_1$  and  $C_2$  are defined as follows:

$$C_1 = \frac{X_{std}}{Y_{std}} \cdot \frac{Y_{meas}}{X_{meas} + X_{b\ meas}}$$

$$C_2 = \frac{Z_{std}}{Y_{std}} \cdot \frac{Y_{meas}}{X_{meas} + Z_{meas}}$$

Where:  $X_{std}$ ,  $Y_{std}$ , and  $Z_{std}$  are the chromaticity coordinates of a known standard which has a spectral energy distribution similar to the device to be measured, and where  $X_{meas}$ ,  $X_{b\ meas}$ ,  $Y_{meas}$ , and  $Z_{meas}$  are actual instrument values measured against this known standard.

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4.4.7.1.2 Compensated computation. Once  $C_1$  and  $C_2$  have been determined using a known similar color standard, the test article may be measured. The formulas to determine the correct chromaticity coordinates are:

$$X = \frac{C_1(X_{\text{red}} + X_{\text{blue}})}{C_1(X_{\text{red}} + X_{\text{blue}}) + Y + C_2(Z)}$$

$$Y = \frac{Y}{C_1(X_{\text{red}} + X_{\text{blue}}) + Y + C_2(Z)}$$

Where:  $X_{\text{red}}$  = Red, or X, tristimulus value;

$X_{\text{blue}}$  = X', or X<sub>b</sub>, tristimulus value;

Y = Photopic tristimulus value; and

Z = Blue tristimulus value;

with  $X_{\text{red}}$ ,  $X_{\text{blue}}$ , Y, and Z representing measurement values on the article under test.

4.4.7.2 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. The accuracy of the spectroradiometer should be equal to or better than  $\pm 0.005$  in x and y for all colors to be tested. After calibration, the spectroradiometer calibration should be validated with either the Marine Engineering Laboratory (MEL) chromaticity reference filters (see Appendix A) 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 Appendix A. Ideally, the spectral transmittances should be measured with a spectrophotometer since improper use of the spectroradiometer may obscure measurement problems.

4.4.7.3 Color of light (class 1-R and 2-R). The panel shall meet the color of light requirements of 3.8 while satisfying the legend color requirements of 3.7.1. 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 (R1) shall be taken. One National Institute of Standards and Technology (NIST) type no. 3215 filter shall then be placed in the optical path between the panel and the photometer. A second reading (R2) shall then be taken. The ratio of R2 to R1 shall be greater than or equal to the value of the IPL Red limit as determined from the calibration curve of the photometer. The IPL Red limit may also be determined by the method described in MIL-L-25467.

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4.4.7.4 Measurement disputes. When disputes arise from color measurements, rejection shall be based upon measurements of the next higher order of accuracy, where spectroradiometer (see Appendix A) measurements take precedence over the four-filter photometer/colorimeter method (see 4.4.7.1).

4.4.7.5 Illumination certification. The manufacturer shall document that the illumination test facility requirements comply with Appendix A of this specification.

4.4.8 NVIS radiance (class 1-NVIS Green A). The panels shall meet the NVIS radiance requirements of 3.9 when tested by a spectroradiometer meeting the requirements of MIL-L-85762. The measured data points shall include the 3 "brighter" areas or characters as identified by a NVIS device (see Appendix A). The areas of maximum NVIS radiance shall be determined visually with the NVIS device by increasing the panel voltage from zero to the rated condition until the first markings visually appear. These markings may have the greatest NVIS radiance values.

4.4.8.1 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 Appendix A. 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.

4.4.9 Light leakage. Each NVIS panel under test shall be examined in the dark environment in accordance with 3.10 and MIL-L-85762 for light leaks. When observed through a NVIS device (see Appendix A), 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.

4.4.10 Gloss. The panel shall meet the gloss requirements of 3.11 when measured in accordance with the ASTM D523 (60 degrees).

4.4.11 Accelerated weathering. The panel shall be exposed for 150 hours to the radiation from a xenon-arc accelerated weathering chamber in accordance with exposure cycle 1 of ASTM G155, using an apparatus capable of automatic programming of temperature and cycles (see 3.12.1). The exposure apparatus shall have automatic humidity control. 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.

4.4.12 Altitude. The panel 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) Hg (see 3.12.2).

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4.4.13 Salt fog test. The panel shall be tested in accordance with method 101 of MIL-STD-202 for 26 hours (see 3.12.3).

4.4.14 Humidity. The panel shall be subjected to ten cycles in accordance with procedure II of method 507 of MIL-STD-810 (see 3.12.4).

4.4.15 Temperature. The panel shall be placed in the chamber maintained at  $-65^{\circ}\text{C}$  ( $-85^{\circ}\text{F}$ ) 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  $+85^{\circ}\text{C}$  ( $+185^{\circ}\text{F}$ ) 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 for black panels or 2.5 for gray panels (see 3.12.5).

4.4.15.1 Operation of lamps. Lamps within the panels subjected to temperature tests shall not be operated in ambient temperatures above  $71^{\circ}\text{C}$ .

4.4.16 Solvents and fluids. A felt pad 0.25 inch (6.35 mm) thick and of 1/2 the area of the panel (see figure 1), shall be saturated with the fluid as required under 3.13. 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 3.13 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.

4.4.17 Surface endurance. The apparatus shall consist of a device that applies 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 6). 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 6 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 6. See 6.5.1 for a source for needles. 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 (see 3.14).

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4.4.18 Radiated emissions (type VII). Type VII panels that incorporate pulse width modulation techniques for luminance dimming shall meet the requirements of 3.12.6 when tested per MIL-STD-461.

4.4.19 Random vibration (type VII). Type VII panels that incorporate pulse width modulation techniques for luminance dimming shall meet the requirements of 3.12.7 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.

4.4.20 Sinusoidal vibration (type VII). Type VII panels that incorporate pulse width modulation techniques for luminance dimming shall meet the sinusoidal vibration requirements of 3.12.8 when tested in accordance with method 201 of MIL-STD-202 in an operating condition in each vibration axis.

## 5. PACKAGING

5.1 Packaging. For acquisition purposes, the packaging requirements shall be as specified in the contract or order (see 6.2). When packaging of materiel is to be performed by DoD or in-house contractor personnel, these personnel need to contact the responsible packaging activity to ascertain packaging requirements. Packaging requirements are maintained by the Inventory Control Point's packaging activities within the Military Service or Defense Agency, or within the military service's system commands. Packaging data retrieval is available from the managing Military Department's or Defense Agency's automated packaging files, CD-ROM products, or by contacting the responsible packaging activity.

## 6. NOTES

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

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 Acquisition requirements. Acquisition 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 (see 1.2).
- c. Whether IPL Red, IPL White, USAF Blue-white, or NVIS Green A light is required when the lighting units are energized (see 1.2).
- d. Packaging requirements (see 5.1).

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6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time of award of contract, qualified for inclusion in QPL-7788 whether or not such products have actually been listed by that date. The attention of the contractors is called to these requirements, 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 may be obtained from DLA Aviation VEB, 8000 Jefferson Davis Highway, Richmond, VA 23297-5616 or [STDZNMGT@dla.mil](mailto:STDZNMGT@dla.mil).

6.4 Illumination test facilities. Refer to Appendix A at the back of this specification for information on illumination test equipment and facilities.

6.5 Test equipment sources. The following list of equipment sources is intended to cover only those special items called for in this specification which are not readily available. Other items are considered to be available from multiple sources or capable of in-house fabrication.

6.5.1 Needles. Surface endurance test needles are available from:

Hoffman Engineering Corporation  
8 Riverbend Drive  
Stamford, CT 06902

6.5.2 Chromaticity reference filters. MEL reference filters may be obtained from:

Hoffman Engineering Corporation  
8 Riverbend Drive  
Stamford, CT 06902

Photo Research  
9731 Topanga Canyon Place  
Chatsworth, CA 92313-2192

6.5.3 Red filters (type 3215). NIST type 3215 Red limit filters may be obtained from:

Hoffman Engineering Corporation  
8 Riverbend Drive  
Stamford, CT 06902

Photo Research  
9731 Topanga Canyon Place  
Chatsworth, CA 92313-2192

Kaelite Corporation  
1440 S. State College Blvd., Suite 4K  
Anaheim, CA 92806

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6.5.4 NVIS radiance filters (class 1-NVIS Green A). Filters for the validation of the spectroradiometer may be obtained from:

Hoffman Engineering Corporation  
8 Riverbend Drive  
Stamford, CT 06902

6.5.5 Surface endurance tester. A surface endurance tester, also known as a balanced-beam scrape-adhesion and mar tester, may be obtained from:

Paul N. Gardner Company, Inc.  
316 N. E. First Street  
Pompano Beach, FL 33060

6.5.6 Gloss meter. A gloss meter may be obtained from:

Paul N. Gardner Company, Inc.  
316 N. E. First Street  
Pompano Beach, FL 33060

6.5.7 Spectroradiometer. Spectroradiometers meeting requirements of MIL-L-85762 may be obtained from:

Photo Research  
9731 Topanga Canyon Place  
Chatsworth, CA 92313-2192

Gamma Scientific  
8581 Aero Drive  
San Diego, CA 92123

6.5.8 NVIS radiance spotmeter. An NVIS radiance spotmeter may be obtained from:

Photo Research  
9731 Topanga Canyon Place  
Chatsworth, CA 92313-2192

6.6 Adapter plug MIL-DTL-32385/7. This adapter plug has been designed to allow the conversion from type III lighting panels which utilize the MS25010 light assemblies to either type IV or V panels. The plug replaces the MS25010 and is screwed into either the MS25010A or MS25010B receptacles located in the control panel box. Any one of the receptacles located in the panel may be used for the adapter insertion. The adapter now provides an electrical connection to the MIL-DTL-32385/5 or /6 plugs which are used in the type IV and V panels, respectively. This conversion allows complete updating of the illumination for all type III panels without modification of any kind to the control panel box.

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6.7 Mockup. A mockup of the lighting panel display should be provided as required by the procuring or qualifying activity.

6.8 Component parts. Component parts are defined as switches, rheostats, and other controls mounted on the mounting plate and requiring lighting by the information panel.

6.9 Metrication. When metric units are preferred, metrication should be performed and should conform to the practices of FED-STD-376. If metrication is utilized, conformance to all of the requirements of this specification should be maintained.

6.9.1 Metric conversion factors. The following conversion factors are applicable to this specification:

Inches x 25.4 = millimeters (mm)

Feet x 0.3048 = meters (m)

Foot-lamberts (fl) x 3.4262591 = candelas per square meter ( $\text{cd}/\text{m}^2$ ) or NITS

Foot-candles (fc) x 10.76391 = lumens per square meter ( $\text{lm}/\text{m}^2$ ) or lux (lx)

Pound = 453.59237 grams (g)

Ounce x 28.349523 = grams

Newton x .22480894 = pounds (lbs.)

6.9.2 Conductor area conversion. The following conductor area conversion factors are applicable to this specification:

A circular inch is the area of a circle 1.0 inch in diameter" or  $0.7854 \text{ in}^2$ .

1 circular inch = 1,000,000 circular mils

1 square inch = 1.2732 circular inch = 1,273,239 circular mils

A circular mil is the area of a circle 0.001 inch in diameter.

One circular mil =  $7.85 \times 10^{-7} \text{ in}^2$

Circular mil =  $1.0 \times 10^{-6}$  circular inches

=  $5.0670748 \times 10^{-6}$  square centimeters ( $\text{cm}^2$ )

=  $7.8539816 \times 10^{-7} \text{ in}^2$

=  $0.00050670748 \text{ mm}^2$

=  $0.78539816 \text{ mil}^2$

A square mil = area of a square which has a width and length of 1 mil (0.001 inch)

1 square mil = 1.273 circular mil

6.10 Conductor issues. The relationship of a minimum cross-sectional area of 254 circular mils of pure copper (see 3.3.3.4) to a specific plating thickness requires additional information. A circular mil is the area of 1 mil or 0.001 inch diameter circle ( $7.85398 \times 10^{-10} \text{ in}^2$  or  $5.0670748 \times 10^{-6} \text{ cm}^2$ ). A square mil is the area of a 1 mil (0.001 inch) square ( $1.0 \times 10^{-6} \text{ in}^2$  or  $6.4516 \times 10^{-6} \text{ cm}^2$ ). A square mil equals 1.273 circular mils. "1 ounce copper" refers to a plating thickness of 1 ounce of copper per square foot. Copper has a density of 8.92 grams per cubic centimeter ( $\text{g}/\text{cm}^3$ ) or 5/156 ounces per cubic inch ( $\text{oz}/\text{in}^3$ ) (or 0.742476 ounces

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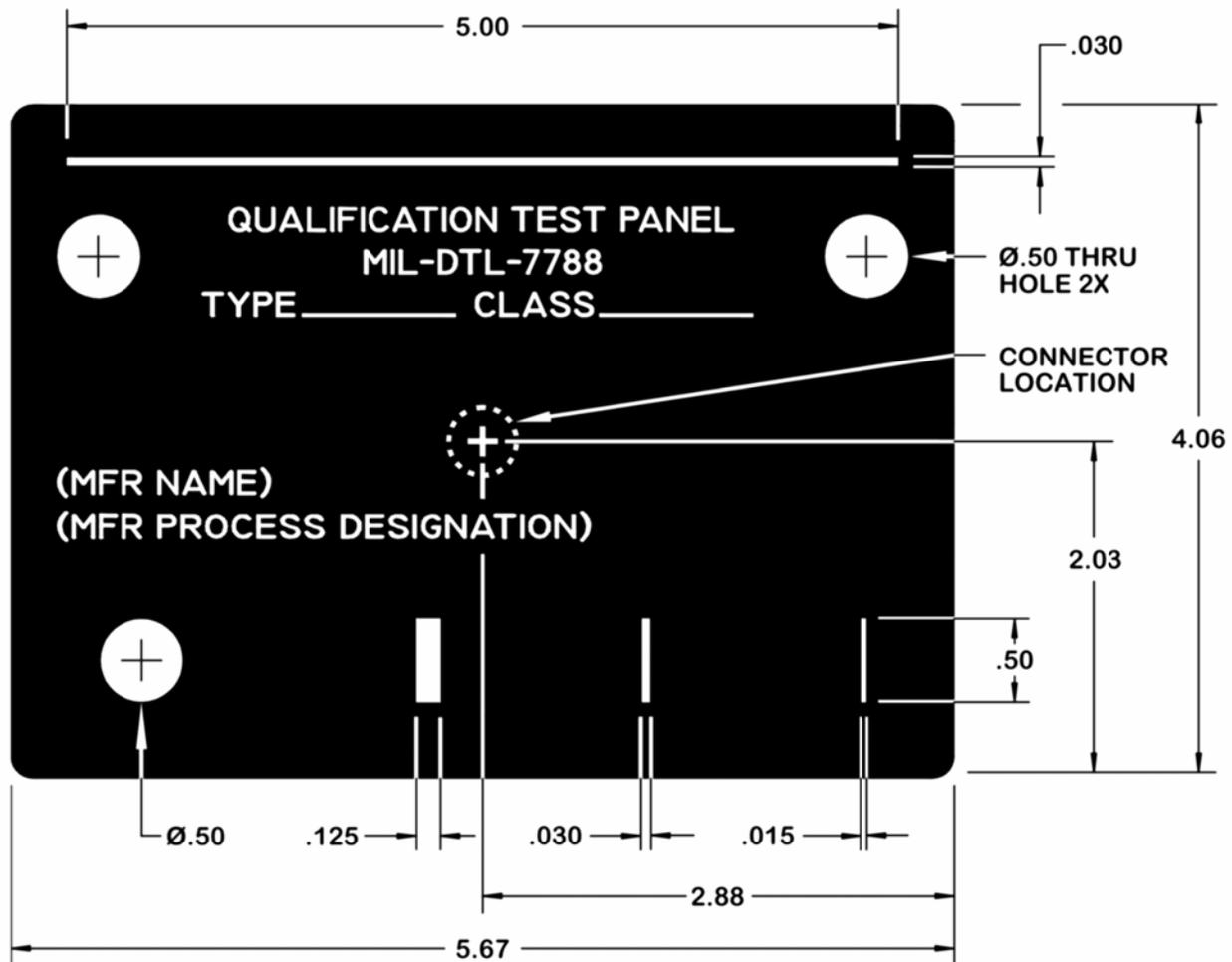
per mil square foot). The product of a conductor width (in mils), a conversion factor, and ounces of copper (ounces per square foot) is the cross sectional area in square mils. The conversion factor is the inverse of the product of copper density and the ratio of square mils to circular mils (conductor width in mils x 1.714 x ounces of copper = circular mils). For example, a 1 ounce copper plating of 148 mils width meets the minimum cross sectional requirements of 254 circular mils; a 2 ounce copper plating of 74 mils width meets the minimum cross sectional requirement of 254 circular mils.

6.11 Subject term (key word) listing.

Colorimetric  
Colorimetry  
Control  
Display  
Glow  
Illumination  
Imaging  
Night vision  
Photometric  
Photometry  
Transilluminance  
Transilluminate

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

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## NOTES:

1. Dimensions are in inches unless otherwise specified.
2. Tolerances: 2-place decimals:  $\pm 0.01$  inch  
3-place decimals:  $\pm 0.005$  inch
3. All letters and numbers shall be 0.156 inch high and in accordance with 3.7 and subparagraphs.
4. Panel will be black or gray in accordance with 3.6.2.1.
5. All letters, numbers, indicia, markings, etc., are white translucent areas per 3.6.2.1.
6. On type IV panels, lamp locations and circuit shall be marked on the rear of the panel in accordance with 3.3.3.4.3.
7. The connector location is marked with a white, non-illuminating cross.

FIGURE 1. Qualification test panels, type IV, V, VI, and VII, all classes.

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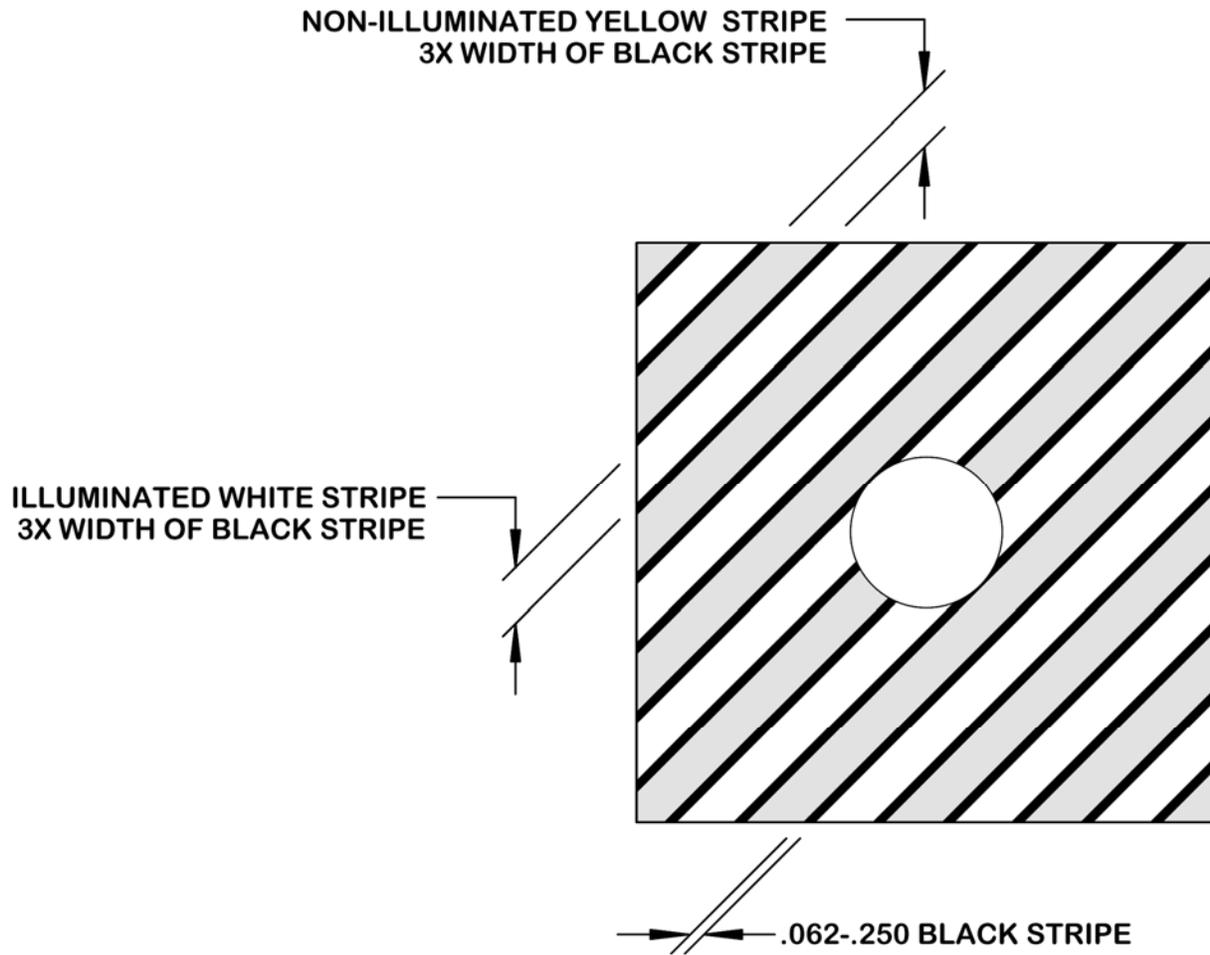


FIGURE 2. NVIS immediate action striping.

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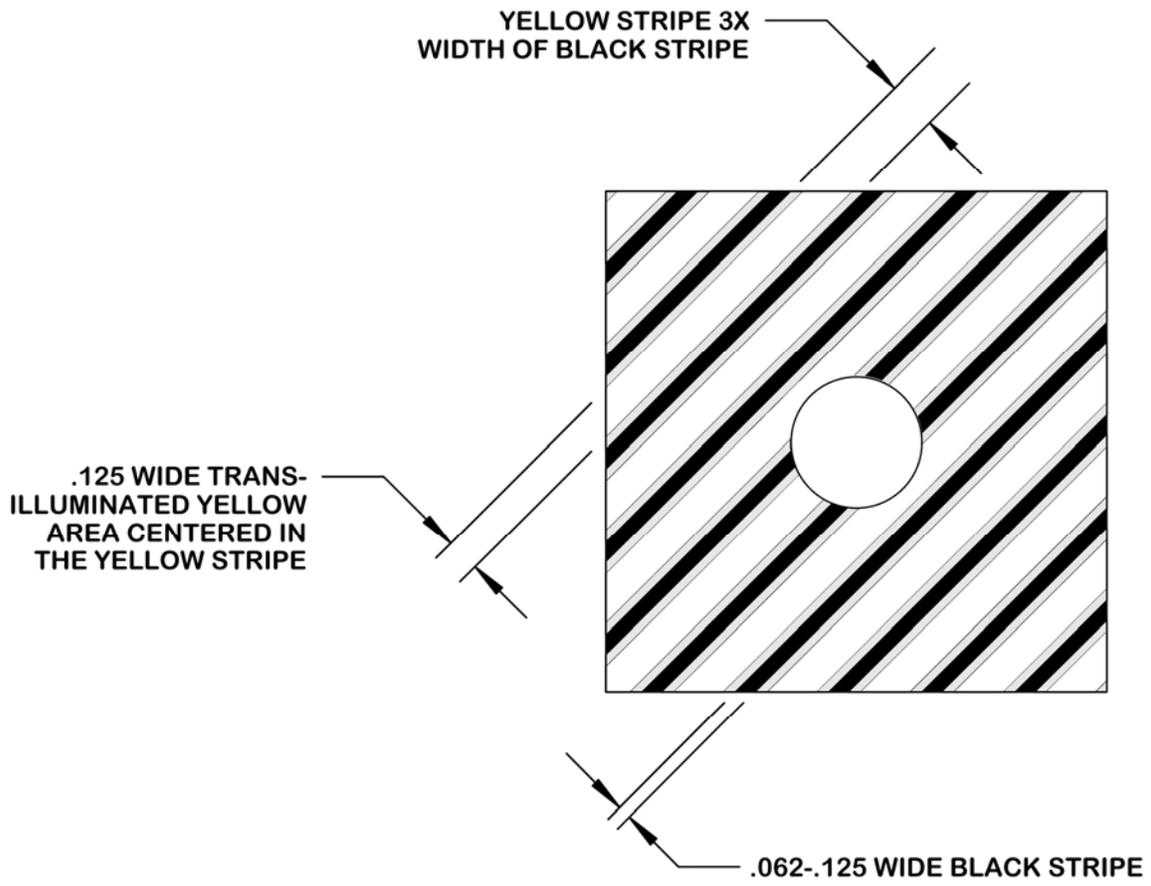
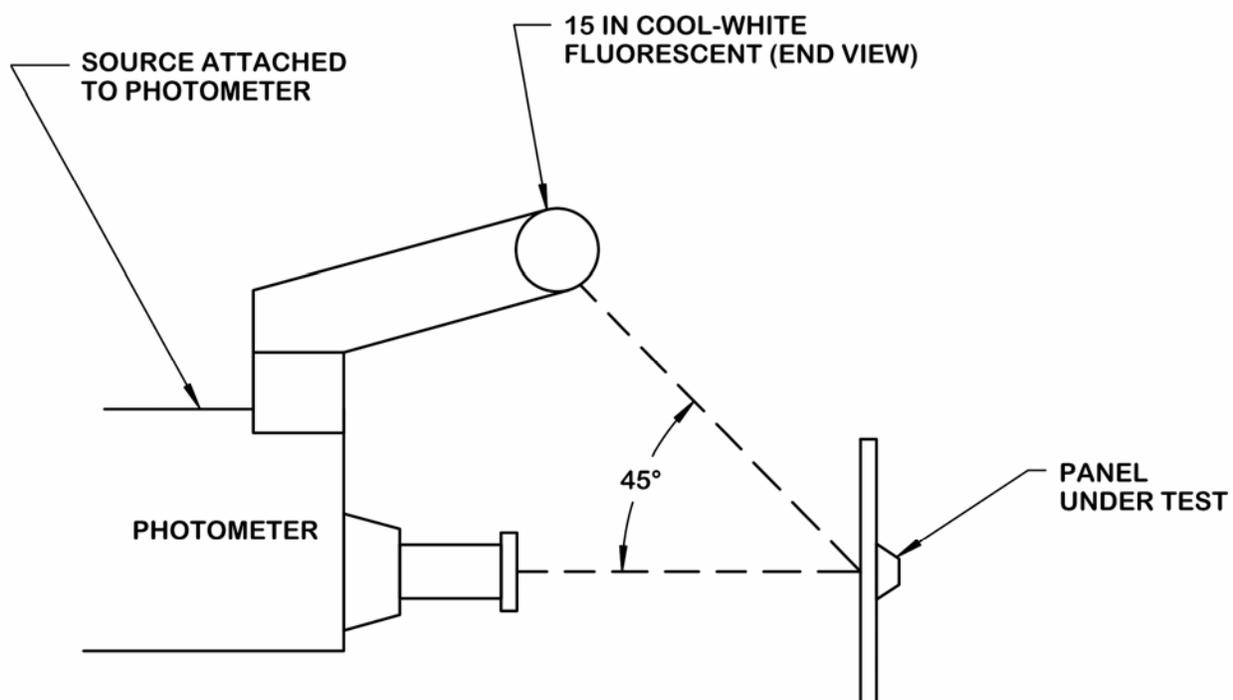


FIGURE 3. Non-NVIS immediate action striping.

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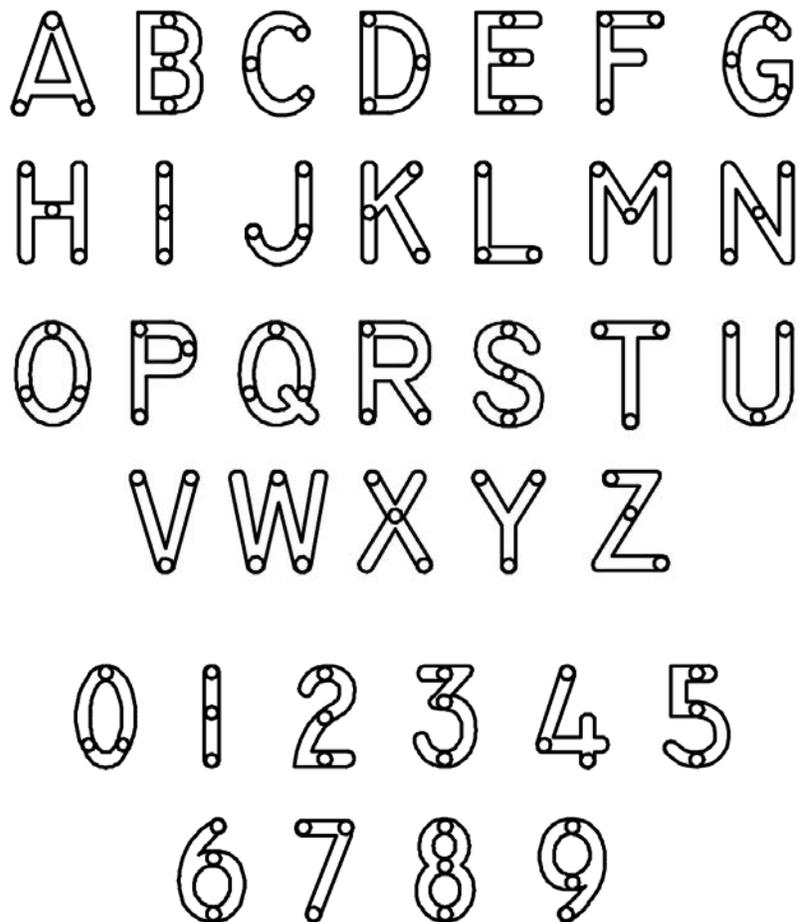


NOTE:

1. Light source not a permanent attachment.
2. Angular and distance requirements to be maintained.
3. Luminance at a panel is approximately 50 foot-candles.
4. See 3.7.2 and 4.4.5.

FIGURE 4. Contrast fixture apparatus.

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## NOTE:

1. Variations may be necessary for other type fonts. However, measurements should be made in the center of the points as shown.

FIGURE 5. Points for character luminance measurements (see 4.4.6).

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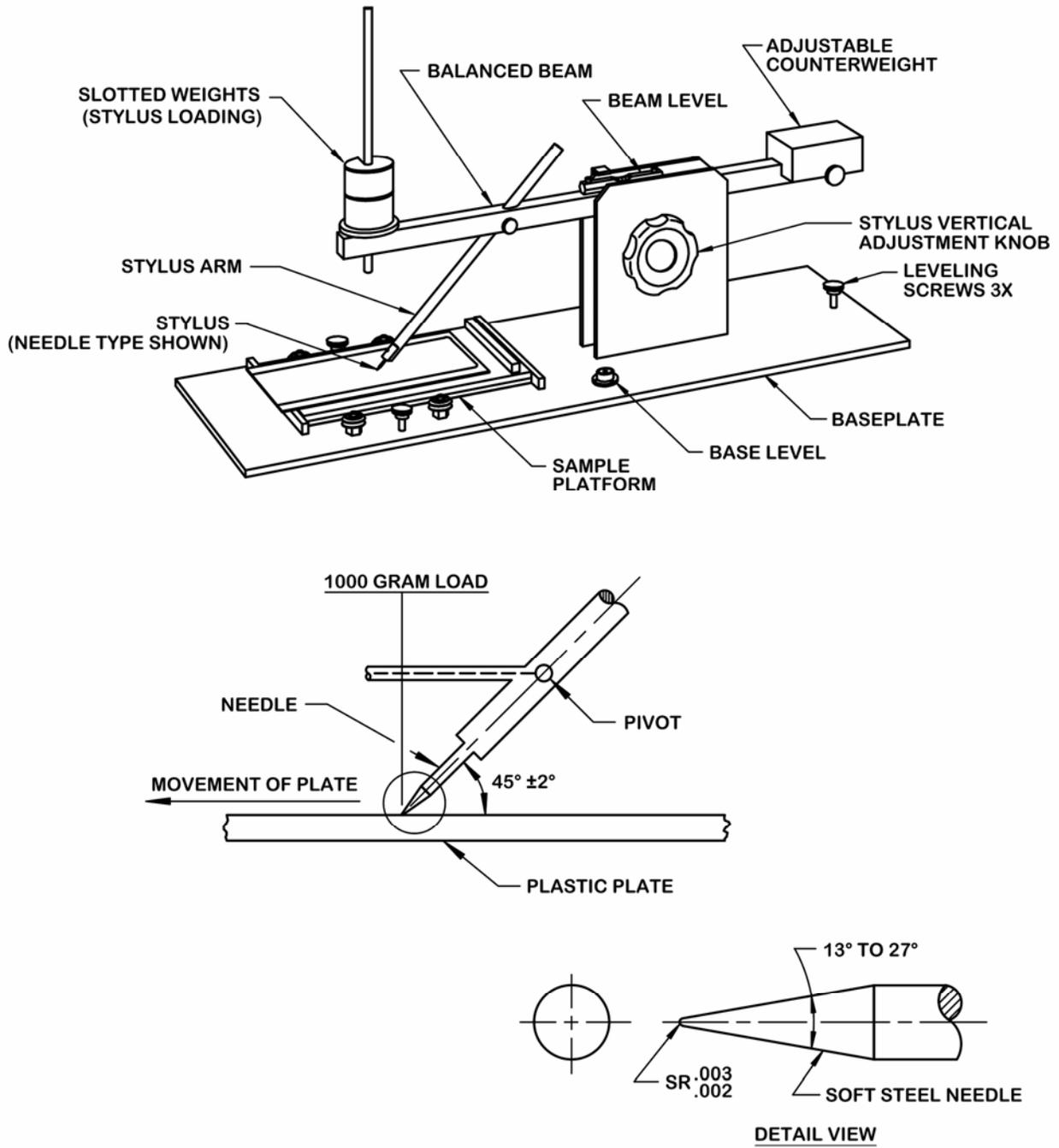


FIGURE 6. Surface endurance test apparatus.

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ILLUMINATION TEST FACILITIES

A.1 SCOPE

A.1.1 Scope. This appendix specifies the test facility requirements that panel manufacturers shall meet in order to qualify illumination panels for listing on the qualified products list associated with this specification. This appendix is a mandatory part of the specification. The information contained herein is intended for compliance.

A.1.2 Applicability. Manufacturers must have the test facilities necessary to make accurate illumination measurements of the markings of panels covered by this specification. Equipment required and procedures for making the required illumination measurements should be documented and reside within the facility of the manufacturer (see table A-I). The following equipment and capabilities represent the minimum test facility requirements for manufacturers of panels procured to this specification.

A.2 APPLICABLE DOCUMENTS

A.2.1 General. The documents listed in this section are specified in Appendix A. This section does not include documents cited in other sections of this specification or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements of the documents cited in Appendix A of this specification, whether or not they are listed.

A.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 these documents are those cited in the solicitation or contract.

ASTM INTERNATIONAL

ASTM E275	- Standard Practice for Describing and Measuring Performance of Ultraviolet and Visible Spectrophotometers
ASTM E925	- Standard Practice for Monitoring the Calibration of Ultraviolet-Visible Spectrophotometers whose Spectral Bandwidth does not Exceed 2 nm
ASTM MNL7A	- Manual on Presentation of Data and Control Chart Analysis

(Copies of these documents are available online at <http://www.astm.org> or from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.)

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## TECHAMERICA

EIA 557

- Statistical Process Control Systems

(Copies of this document are available on-line at <http://www.techamerica.org> or from TechAmerica, 1401 Wilson Blvd., Suite 1100, Arlington, VA 22209.)

## A.3 TEST EQUIPMENT

A.3.1 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 inch (minimum)
- b. Minimum full scale sensitivity: 0.1 foot-lambert
- c. Stability:  $\pm 2$  percent zero and sensitivity combined drift over 8 hour period after 15 minute initial warm-up
- d. Polarization error: 1 percent maximum
- e. Viewing system: must locate spot being measured with maximum error of 0.002 inch
- f. Unit should have digital readout with a resolution of no less than 0.1 percent of full scale.
- g. A unit with a fixed focus lens system with a capability of inserting two 2 inch square filters into the optical path is preferred.
- h. Colorimetric trim:
  1. Maximum correction IPL Red light (3215 Red vs. 2856 Kelvin):  $\pm 10$  percent of filter transmittance.
  2. Four-filter tristimulus colorimetric capability - maximum error for any black body (lamp) color temperature:  $\pm 0.005$  x and y from 1800 to 2856 Kelvin (K) when calibrated at 2856K for an ambient temperature excursion of  $70^\circ\text{F} \pm 5^\circ\text{F}$ .
- i. Annual certification that the photometric equipment meets all of the above parameters is required (see table A-I).

NOTE: A video-based image processing and analyzing light meter may be equivalent to the photometer (see A.3.1.) provided a correlation has been established with the photometer. The number of display pixels illuminated by a measurement area equivalent to A.3.1.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 (see A.3.1.c), it may be necessary, due to signal-to-noise detector characteristics, to increase the requirement to four times the Nyquist sampling requirement.

A.3.2 Spectroradiometer (class 1-NVIS Green A). The spectroradiometer should meet the requirements of MIL-L-85762.

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A.3.3 Test equipment (electrical).

A.3.3.1 Voltmeters, DC.

- a. Display: digital readout (4 full digits minimum)
- b. Ranges: 0-20, 0-120 (minimum ranges)
- c. Accuracy:  $\pm 0.05$  percent

A.3.3.2 Ammeter.

- a. Display: digital readout (4 full digits minimum)
- b. Range: 0-5 ampere (minimum range)
- c. Accuracy:  $\pm 0.07$  percent

NOTE: Suitable shunts may be used with the above voltmeter providing the shunt and voltmeter combined accuracy meets the ammeter accuracy of  $\pm 0.07$  percent.

A.3.3.3 Power supply, DC (for panel operation).

- a. Range: 0-30 volts minimum
- b. Current: 0-5 ampere
- c. Regulation: 0.05 percent line, maximum ripple 2 millivolts (mV) root-mean-square (rms)

A.3.3.4 Power supply, AC (type VI qualification inspection).

- a. Range: nominal 0 to 115 VAC (minimum)
- b. Current: nominal 0 to 1 ampere maximum
- c. Frequency:  $400 \pm 5$  Hz minimum
- d. Waveform: sine wave (minimum)
- e. Harmonic distortion: less than -20 decibels (dB) relative to fundamental at full output at 400 Hz
- f. DC offset: 1 volt maximum

A.3.3.5 Power supply, DC (for luminance standards)

- a. Range: 0 to 130 volts (minimum)
- b. Current: 0-8 ampere (minimum)
- c. Regulation: 0.02 percent line
- d. Maximum ripple: 10 mV rms
- e. Stability under load: 0.05 percent per hour

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A.3.3.6 Power supply, DC, for spectral radiance standards (class 1-NVIS Green A).

- a. Range: 0-10 volts (minimum)
- b. Current: 0-42 ampere (minimum)
- c. Regulation: 0.02 percent line
- d. Maximum ripple: 10 mV rms

A.3.3.7 Insulation resistance tester.

- a. Voltage: AC: 500 volts AC, 60 Hz, DC: 500 volts DC
- b. Current: 50  $\mu$ A

A.3.3.8 Gloss meter. Meets the requirements of 4.4.10.

A.3.4 Test equipment (standards with NIST traceability).

A.3.4.1 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 A.3.3.5 may be deleted. If a self-contained calibration system is provided, then the characteristics of A.4.1.2 may also be deleted. Recalibration should be based upon the manufacturer's recommendations for usage but should be performed at least annually.

- c. Red filters: At least one type NBS3215 filter is required.

d. Chromaticity reference (MEL) 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.)

A.3.4.2 NVIS radiance (class 1-NVIS Green A).

a. NVIS radiance (class 1-NVIS Green 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

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nanometer increments at a nominal 1 foot-lambert. The spectral radiance values should be accurate to within  $\pm 2$  percent. The color coordinates should be  $x = 0.4476 \pm 0.001$  and  $y = 0.4075 \pm 0.003$ . 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 procuring or qualifying activity has approved the calibration test procedures. The A.3.3.5 power supply would be needed. If the system is self-powered, then the standard DC power supply described in A.3.3.5 and A.3.3.6 may be deleted. If a self-contained calibration system is provided, then the characteristics of A.4.1.2 may also be deleted. Recalibration should be based upon the manufacturer's recommendations for usage, but should be performed at least annually.

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 [a short wave pass (SWP) filter] with a nominal transition or cut-off wavelength of 600 nanometers (nm) at a transmittance level of 5 percent. The spectral transmittance of this filter should be known within an accuracy of  $\pm 2$  percent from at least 380 to 930 nm in 5 nm increments. Spectral transmittance levels are to be measurable to  $1.0 \times 10^{-7}$  within the 600 to 930 nm 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 nm or less. The spectrophotometer or spectroradiometer should be calibrated in accordance with ASTM E275 or ASTM 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 (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.

#### A.4 CAPABILITIES

##### A.4.1 Dark room facilities.

A.4.1.1 Dark room. A room designed to provide a dark environment per 4.2.2 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  $70 \text{ }^\circ\text{F} \pm 5 \text{ }^\circ\text{F}$  ( $21.1 \text{ }^\circ\text{C} \pm 2.8 \text{ }^\circ\text{C}$ ) ambient temperature. For

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class 1-NVIS Green A panels, the dark room should meet the dark environment requirements of MIL-L-85762.

A.4.1.2 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.

A.4.1.3 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.

#### A.5 STATISTICAL PROCESS CONTROL (SPC) FOR GUIDANCE ONLY

A.5.1 SPC (class 1-NVIS Green A). The manufacturer should implement and use SPC methods to monitor the process control for NVIS radiance 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 (that is, the manufactured items, the process(es) producing them, and their methods of measure are under statistical 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 MNL7A. Evidence of such compliance should be verified by the procuring or qualifying activity as a prerequisite for product acceptance. Under special circumstances, an alternative process control program may be acceptable subject to approval of the procuring or qualifying activity.

A.5.2 Spectroradiometer measurement process (class 1-NVIS Green A). The spectroradiometer measurement system should meet the requirements of MIL-L-85762 and should be calibrated and validated with a filter (see A.3.4.2(b)) plus spectral radiance lamp (see A.3.4.2(a)) combination. The validation phase requires an optical filter meeting the requirements of A.3.4.2(b) and maintaining 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 half-power bandwidth (HPBW) to measure spectral transmittance.) The spectrophotometer or spectroradiometer should be calibrated for wavelength and linearity per ASTM E275 and ASTM 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  $1.0 \times 10^{-08}$ . 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 value should agree within 10 percent of the calculated NVIS radiance value that is generated by mathematically inserting the

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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 percent. On a periodic basis, the measured value of this filter plus spectral radiance source should be monitored by SPC technique. Whenever the validation test fails or the control chart shows an abrupt unexplainable discontinuity, the spectroradiometer should be deemed unacceptable for further NVIS radiance testing until the problem is resolved and the operator reestablishes statistical process control over the process. 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 (Xbar) to the certified value of the standard; Xbar should not differ by more than  $\pm 10$  percent 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 to bring the measurement process back into control.

A.5.3 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/movR control chart as discussed in A.5.1. 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.

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TABLE A-I. Illumination test facility certification specification summary.

MIL-DTL-7788 requirements	Paragraph no.	Calibrated	Available
Photometer	A.3.1		
Spectroradiometer	A.3.2	**	
DVM, 0-20, 120V, 0.05%, 4 digits	A.3.3.1		
Ammeter, 5A, 0.07%, 4 digits	A.3.3.2		
Current shunt, 5A, 0.02%	A.3.3.2		
Power supply, 30V, 5A (panels)	A.3.3.3		N/A
Power supply, 115V, 400 Hz (panels)	A.3.3.4		N/A
Power supply, 130V, 5A (luminance stds.)	A.3.3.5	*	N/A
Power supply, 10V, 42A (spec. rad. stds.)	A.3.3.6	*	N/A
500W med. bipost, 130V, 5A (lum. std.)	A.3.4.1a	*	
Color temperature std, 500W, 1800-2856K	A.3.4.1a	*	
Opal glass, lum. direct. trans.	A.3.4.1b	*	
Equivalent std. luminance & color	A.3.4.1		
30A/T24/13 (NVIS spectral radiance std.)	A.3.4.2	*	
Equivalent std. spectral radiance	A.3.4.2		
3215 Red filter	A.3.4.1c		
MEL filters	A.3.4.1d		
NVIS radiance filter	A.3.4.2b	**	
Contrast fixture	4.4.5		
Dark room, 70 °F ±5 °F	A.4.1.1		N/A
9 ft optics bench, baffles, accessories	A.4.1.2	*	N/A
Positioner for photometer (H&V)	A.4.1.3		
Needles	6.5.1		
Insulation resistance tester	A.3.3.7		
Gloss meter	A.3.3.8		
Written procedures	A.1.2		

\* Not required if appropriate equivalent standards are used.

\*\* Required for NVIS only

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Custodians:

Army - AV  
Navy - AS  
Air Force - 99  
DLA - GS

Preparing Activity:

DLA - GS2

(Project 6220-2011-003)

Review Activity:

DLA - IS

NOTE: The activities listed above were interested in this document as of the date of this document. Since organizations and responsibilities can change, you should verify the currency of the information above using the ASSIST database at <https://assist.daps.dla.mil/>.