



# Standard Specification for Solid State Bargraph Meters for Shipboard Use [Metric]<sup>1</sup>

This standard is issued under the fixed designation F 1755M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last approval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This specification provides the requirements for design, construction, performance, and testing of solid state bargraph-type indicating meters.

1.2 The solid state bargraph meters covered by this specification are intended for use in shipboard applications of electrical measurement. This specification covers the requirements and quality assurance provisions for solid state, panel-type (edgewise), and rectangular switchboard-type instruments, which use light-emitting diodes (LEDs) for bargraph indication and optional digital displays.

1.3 This specification's requirements may be invoked for specialized measurement applications where another quantity, for example, position, weight, concentration of a trace element in an atmosphere sample, and so forth, is converted to electrical energy for display and measurement. Special dial markings shall be specified for such cases.

1.4 The values stated in metric units are to be regarded as the standard. The values given in parentheses are for information only.

## 2. Referenced Documents

### 2.1 ASTM Standards:

B 117 Practice for Operating Salt Spray (Fog) Apparatus<sup>2</sup>

D 3951 Practice for Commercial Packaging<sup>3</sup>

F 1166 Practice for Human Engineering Design for Marine Systems, Equipment and Facilities<sup>4</sup>

### 2.2 Federal Specifications:

TT-E-529 Enamel, Alkyd, Semigloss, Low VOC Content<sup>5</sup>

### 2.3 Federal Standards:

H28 Screw Thread Standards for Federal Services<sup>5</sup>

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.10 on Electrical.

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<sup>2</sup> Annual Book of ASTM Standards, Vol 03.02.

<sup>3</sup> Annual Book of ASTM Standards, Vol 15.09.

<sup>4</sup> Annual Book of ASTM Standards, Vol 01.07.

<sup>5</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5098, ATTN: NPODS.

3.1.1 *accuracy, n*—the accuracy is a number that defines the limit of errors expressed as a percentage of full-scale value.

3.1.2 *center-zero meter, n*—meter with display mode characterized by a sequentially illuminated string of LEDs starting at the center scale zero position and extending in either direction from zero, proportional to the polarity and magnitude of the input signal.

3.1.3 *dual bargraph display, n*—two completely independent bargraph displays included in a single enclosure.

3.1.4 *end-scale value, n*—the value of the actuating electrical quantity that corresponds to end scale indication. When zero is not at the end or at the electrical center of the scale, the higher value is used. See Table 1.

3.1.5 *end-zero meter, n*—meter with display mode characterized by a sequentially illuminated string of LEDs starting from a zero point, normally at the left for switchboard-style meters or horizontally installed edgewise meters, or the bottom of vertically installed edgewise meters, that extends in the direction of full-scale value.

3.1.6 *full-scale value, n*—full-scale value is the largest value of the actuating electrical quantity, which can be indicated on the scale. For instruments with zero between the ends of the scale, the full-scale value is the arithmetic sum of the values of the actuating electrical quantity corresponding to the two ends of the scale.

3.1.7 *response time, n*—the response time is the time required for the indicating means to display a new value after a step change has occurred in the measured quantity to a new constant value.

3.1.8 *scale division, n*—a scale division is the increment between the centers of two consecutive scale marks. The number of scale marks is one more than the number of scale divisions. For example, 10 scale divisions require 11 scale marks.

3.1.8.1 *linear scale divisions, n*—linear scale divisions are scale divisions that are spaced an equal distance apart and of the same value, for example, scale divisions spaced 5 A apart on a 100-A meter.

3.1.8.2 *nonlinear scale divisions, n*—nonlinear scale divisions are scale divisions of the same value spaced an unequal distance apart.

**TABLE 1 End-Scale Values**

Range	End-Scale Values (for Ratings)	End-Scale Values
0-150	0, 150	150
50-0-150	50, 150	150
150-0-150	150, 150	150
90-140	90, 140	140

3.1.9 *scale length, n*—the scale length is the length of the path described by the pattern of the LEDs in moving from one end of the scale to the other. For multiple scale meters, the longest scale shall be used to determine the scale length.

3.1.10 *scale visibility, n*—scale visibility is the maximum horizontal or vertical viewing angle measured from a line normal to the scale from which all scale marks and arcs, but not necessarily all markings, may be seen.

#### 4. Classification

4.1 *Classification*—Bargraph meters covered in this specification shall be classified by type and style as specified in 4.2-4.3.

4.2 *Type*—The type designation defines the physical configuration of the meter and the scale.

4.2.1 Rectangular/switchboard-type meters present angular displays from 90 to 270° scale for the measured parameter(s). Fig. 1 provides typical dimensional and mounting data for rectangular/switchboard-type meters.

4.2.2 Edgewise/panel-type meters present linear displays for measured parameters. Fig. 2 provides typical dimensional and mounting data for edgewise type meters.

4.2.2.1 *Orientation of Meter*—For edgewise/panel-type meters, the scale marking shall be specified either for a vertical or horizontal mounting condition.

4.3 *Style*—The style designation defines the meters display attributes as follows:

4.3.1 *Bargraph Display*—The bargraph display shall consist of light-emitting diode (LED) elements that illuminate to produce a bar image proportional to the input signal. The display designation defines whether the meter has single or dual bargraph displays.

4.3.2 *Digital Display*—The digital display designation defines the number of digits in the digital display as follows:

- 4.3.2.1 3-digit display.
- 4.3.2.2 3½-digit display.
- 4.3.2.3 4-digit display.
- 4.3.2.4 4½-digit display
- 4.3.2.5 No digital display.

#### 5. Ordering Information

5.1 Purchase orders or inquiries for bargraph meters of this specification shall specify the following:

- 5.1.1 Title, date, and year of this specification.
- 5.1.2 Quantity.
- 5.1.3 Type and for edgewise meter, the orientation (see 4.2).
- 5.1.4 Style of display (single or dual, digital display) (see 4.3).
- 5.1.5 Window type (plastic or shatterproof glass) (see 7.5).
- 5.1.6 Dial colors (see 7.9.1.1).

5.1.7 Range(s) (see 7.9.2).

5.1.8 Power supply voltage (see 8.1.1).

5.1.9 Signal input (analog or digital) (see 8.1.2).

5.1.10 Color(s) of bargraph display (see 8.2.2).

5.1.11 Optional features available:

5.1.11.1 Anti-glare windows (see 7.5.1).

5.1.11.2 Splashproof or spraytight window (see 7.5.2).

5.1.11.3 Internal illumination (see 7.6).

5.1.11.4 External accessories (see 7.8).

5.1.11.5 Alarm set points (see 8.1.4).

5.1.11.6 Digital display:

5.1.11.7 Nonstandard range values (see 8.2.4).

5.1.11.8 Dot matrix display types (see 8.2.4).

5.1.11.9 Intensity control (see 8.2.5).

5.1.12 Certification requirements (See 10).

5.1.13 Packaging requirements.

5.1.14 Testing requirements (include only if tests other than the production tests required by this specification are to be performed).

#### 6. Materials and Manufacture

6.1 *Materials*—All materials used in the construction of these bargraph meters shall be of a quality suitable for the purpose intended and shall conform to the requirements of this specification.

6.1.1 *Metals*—Metals and the treatment of metals shall be corrosion-resistant.

6.1.2 *Plastics*—Plastic, when used, shall be suitable thermoplastic or thermosetting material so molded as to produce a dense solid structure, uniform in texture, finish, and mechanical properties.

6.1.3 *Glass*—Glass used for the meter window shall be the shatterproof type.

6.1.4 *Gaskets*—Material used in gaskets shall not cause corrosion of metal parts with which they come in contact.

6.2 *Manufacture:*

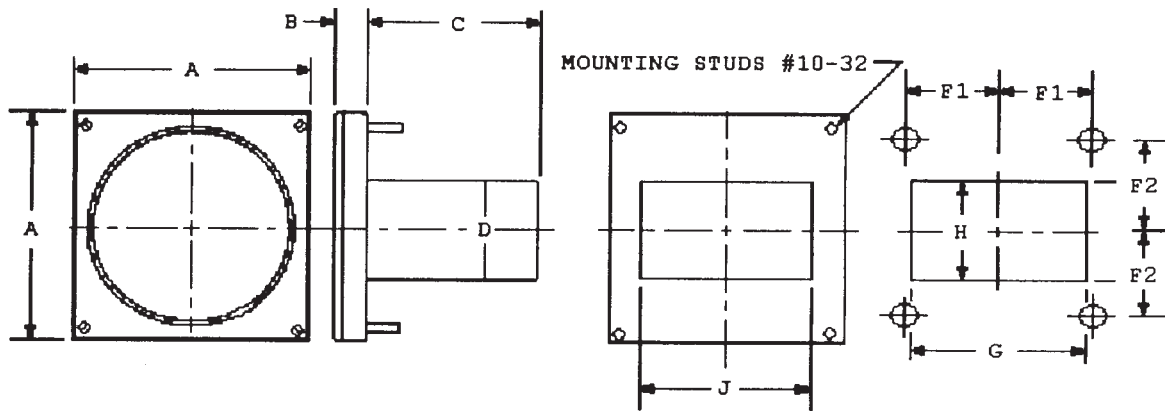
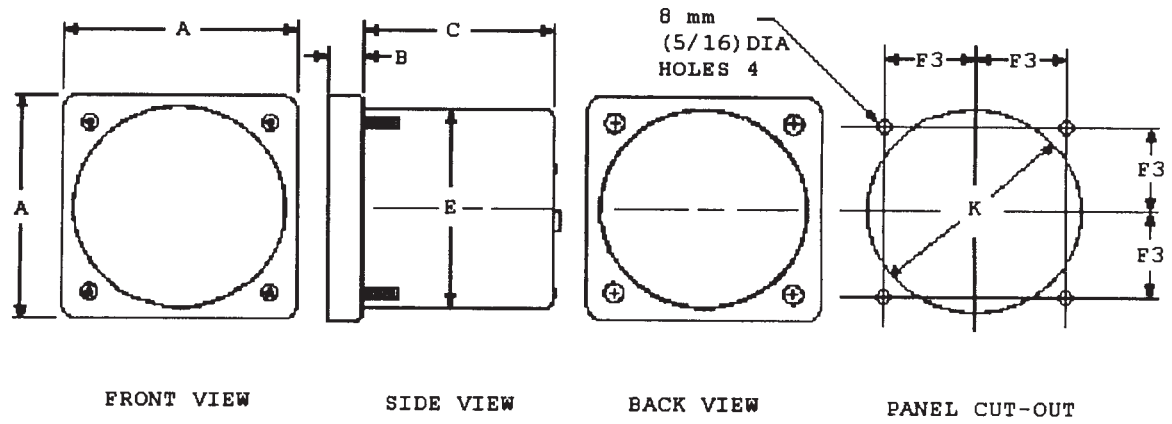
6.2.1 *Finishes:*

6.2.1.1 *External Finishes*—The portion of the meter case exposed to view from the front of the panel or switchboard shall have a black semigloss finish. No nickel or bright trimmings shall be used. The external finish may be epoxy-coated, electro-coated, or painted in accordance with TT-E-529. Metal cases shall be rendered resistant to corrosion prior to the application of the final finish.

6.2.1.2 *Internal Finishes*—Internal finishes shall be of a material that shall not melt, crack, chip, blister, or scale as a result of the tests specified herein.

6.3 *Threaded Parts*—Threaded parts shall be in accordance with FED-STD-H28. Where practical, threads shall be in conformity with the coarse-thread series. The fine-thread series shall be used only for applications that might show a definite advantage through their use. Where a special diameter pitch combination is required, the thread shall be of American National Form and of any pitch between 16 and 36 which is used in the fine-thread series.

6.3.1 *Locking of Screw-Thread Assemblies*—Screw-thread assemblies shall not loosen as a result of the tests specified herein. When practicable, split-type lockwashers or equivalent means shall be provided under all nuts.

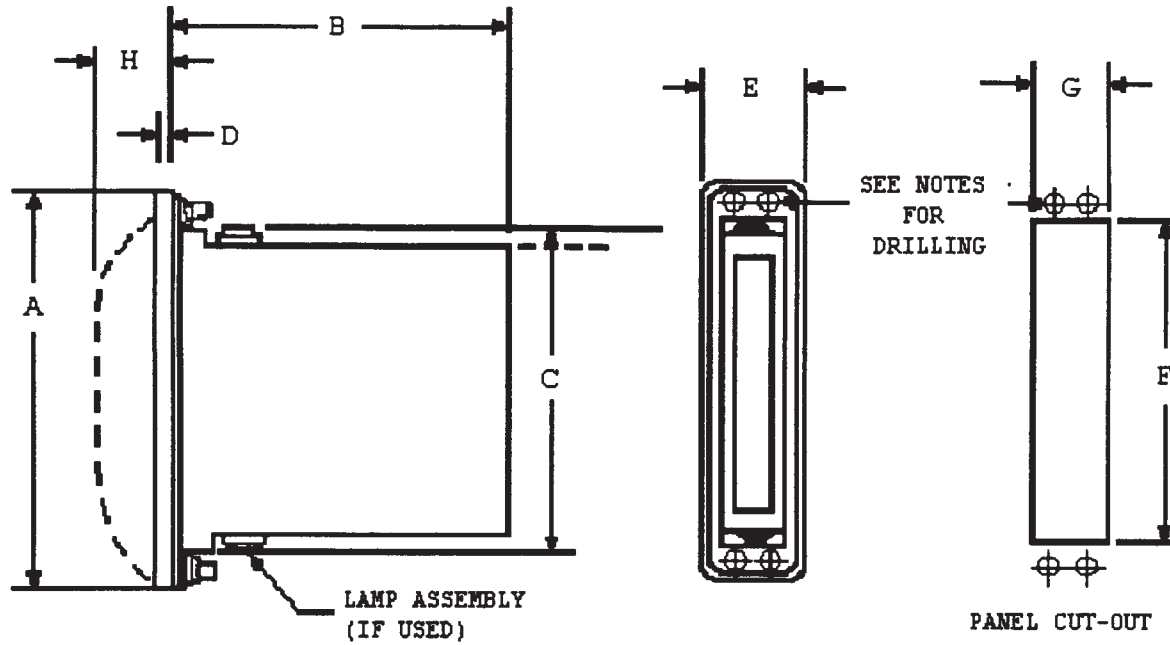


**DIMENSIONAL CHARACTERISTICS FOR RECTANGULAR/SWITCHBOARD-TYPE METERS**

A	B	C	D	E	F <sub>1</sub>	F <sub>2</sub>	F <sub>3</sub>	G	H	J	K
112 mm (4.43 in)	17.4 mm (0.69 in)	135 mm (5.31 in)	—	101 mm (3.98 in)	—	—	43 mm (1.69 in)	—	—	—	101.6 mm (4.0 in)
216 mm (8.75 in)	26.2 mm (1.03 in)	135 mm (5.31 in)	—	101 mm (3.98 in)	—	—	43 mm (1.69 in)	—	—	—	101.6 mm (4.0 in)
123 mm (4.84 in)	19 mm (0.75 in)	142 mm (5.6 in)	50.8 mm (2.0 in)	—	43 mm (1.69 in)	43 mm (1.69 in)	—	114 mm (4.49 in)	54 mm (2.13 in)	109 mm (4.3 in)	—
118 mm (4.63 in)	22.3 mm (0.88 in)	142 mm (5.6 in)	50.8 mm (2.0 in)	—	43 mm (1.69 in)	43 mm (1.69 in)	—	95 mm (3.75 in)	57 mm (2.25 in)	86 mm (3.38 in)	—
118 mm (4.63 in)	22.3 mm (0.88 in)	142 mm (5.6 in)	50.8 mm (2.0 in)	—	43 mm (1.69 in)	43 mm (1.69 in)	—	114 mm (4.49 in)	54 mm (2.13 in)	108 mm (4.26 in)	—
181 mm (7.13 in)	22.3 mm (0.88 in)	217 mm (8.55 in)	40.6 mm (1.6 in)	—	63.5 mm (2.5 in)	83 mm (3.26 in)	—	172 mm (6.78 in)	47 mm (1.84 in)	137 mm (5.38 in)	—

NOTES: All dimensions are in millimeters (inches are in parenthesis and are nominal unless otherwise specified).

FIG. 1 Rectangular/Switchboard/Type Meters



A	B	C	D	E	F	G	H
133.35 mm (5.25 in)	131.95 mm (5.20 in)	-	14.61 mm (0.58 in)	36.53 mm (1.44 in)	110.74 mm (4.36 in)	36.58 mm (1.44 in)	22.99 mm (0.91 in)
146.55 mm (5.77 in)	140.0 mm (5.5 in)	116.8 mm (4.6 in)	15.5 mm (0.61 in)	31.0 mm (1.22 in)	118.1 mm (4.65 in)	26.9 mm (1.06 in)	---
152.4 mm (6.0 in)	171.0 mm (6.73 in)	144.1 mm (5.675 in)	13.7 mm (0.54 in)	54.86 mm (2.16 in)	144.78 mm (5.7 in)	45.0 mm (1.77 in)	---
152.4 mm (6.0 in)	217.2 mm (8.55)	136.5 mm (5.375 in)	20.3 mm (.80 in)	44.2 mm (1.75 in)	172.2 mm (6.78 in)	46.7 mm (1.84 in)	---
170.2 mm (6.7 in)	154.0 mm (6.06 in)	116.8 mm (4.6 in)	15.5 mm (0.610 in)	38.86 mm (1.53 in)	139.1 mm (5.475 in)	31.5 mm (1.24 in)	---
177.8 mm (7.0 in)	184.2 mm (7.25 in)	138.9 mm (5.47 in)	12.7 mm (0.5 in)	63.5 mm (2.50 in)	139.7 mm (5.5 in)	47.6 mm (1.875 in)	41.3 mm (1.625 in)
241.3 mm (9.5 in)	114.3 mm (4.5 in)	182.9 mm (7.2 in)	20.3 mm (0.8 in)	45.72 mm (1.8 in)	184.2 mm (7.25 in)	38.1 mm (1.5 in)	---
254.0 mm (10.0 in)	269.2 mm (10.6 in)	215.1 mm (8.47 in)	12.7 mm (0.5 in)	91.95 mm (3.62 in)	215.9 mm (8.5 in)	76.2 mm (3.0 in)	63.5 mm (2.5 in)
285.7 mm (11.25 in)	217.2 mm (8.55 in)	136.5 mm (5.375 in)	20.8 mm (.820 in)	91.7 mm (3.6 in)	172.2 mm (6.78 in)	46.7 mm (1.84 in)	---

NOTES: All dimensions are in millimeters (inches are in parentheses and are nominal unless otherwise specified). For specific drilling information, contact the manufacturer.

FIG. 2 Dimensional Characteristics of Edgewise Meters

6.4 *Sealing*—The meter case shall be sealed by means of gaskets, by fusing or soldering metal-to-metal or metal-to-glass, or other means which will enable the meter to withstand the tests specified herein.

## 7. Design and Construction

7.1 *Dimensional Data*—Typical physical dimensions for switchboard and edgewise meters are shown in Fig. 1 and Fig. 2.

7.2 *Mounting*—Bargraph meter shall be front panel mounted to simplify mechanical installation or removal for service, or both. Electrical connections locations shall be designed to facilitate meter removal. Typical mounting dimensions are indicated in Fig. 1 and Fig. 2.

7.2.1 *Mounting Hardware*—The necessary mounting hardware, such as mounting clips, nuts, washers, bolts, shall be supplied with each meter. The machine screws shall have the same finish as the external finish (see 6.2.1.1).

7.3 *Maintainability*—The meter shall be constructed so that no special tools are required for insertion or removal of the meter.

7.4 *Cases*—Cases shall be corrosion resistant. Cases shall be designed and constructed with close-fitting joints to minimize the entrance of dust and moisture (see 6.4).

7.5 *Windows*—The meter display shall be provided with a window of methyl methacrylate (MMA), polycarbonate (PC), or shatterproof glass. If the window is made MMA or PC, the external surface shall be treated to resist scratching. The window shall be free from detrimental defects that would prevent the display from being easily read or from meeting the luminous distribution and color requirement. such defects include electrostatic effects, scratches, chips, cracks, or craze.

7.5.1 *Anti-Glare Coatings*—When anti-glare is specified, windows shall be coated with an anti-glare coating. The coating shall be uniform in quality and condition, clean, smooth, and free from foreign materials. The coating shall show no evidence of flaking, peeling, or blistering. The coating shall not contain blemishes such as discolorations, stains, smears, and streaks. The coating shall show no evidence of a cloudy or hazy appearance.

7.5.1.1 *Specular Reflectance*—The coating reflectance shall be not greater than 0.6 % for energy incident on the surface at an angle of 0 to 15° inclusive. The reflectance shall be not greater than 1.0 % at an angle of 30°.

7.5.1.2 *Light Loss*—The coating light loss shall be not greater than 2.0 %.

7.5.2 *Splashproof/Spraytight Windows*—When specified, splashproof or spraytight windows shall be furnished.

7.6 *Internal Illumination*—When specified, meters shall be equipped with internal illumination provided by a minimum of two lamps, so placed to illuminate the dial evenly.

7.7 *Auxiliary Components*—All connections from the shunts and resistors to the input terminals of the meters shall be insulated to prevent shock hazard.

7.8 *External Accessories*—External shunt, shunt leads, transformers, resistors, and other external accessories shall be furnished when required.

7.9 *Meter Scales*:

7.9.1 *Dial*—The dial shall be made of stiff material and shall be supported and secured firmly to the meter.

7.9.1.1 *Dial Colors*—The meter dial shall have white markings on a black background as standard.

7.9.1.2 *Dial Markings*—Dial legend markings shall be sharply defined and visible from the front of the case but not distract attention from the scale markings. Unless otherwise specified, the following information shall be marked on the dial or on an attached nameplate.

(a) Manufacturer's name.

(b) Units of measurement.

(c) The quantity producing end-scale deflection. For end-zero meters, the dial markings shall be FS, indicating full scale, followed by the full-scale value and units of measurement, for example, FS-50 mV). For meters that are not end-zero meters, the dial markings shall be marked ES indicating end scale followed by the end-scale value and units of measurement, for example, ES-50 mV).

7.9.2 *Ranges*—For end-zero meters, the full-scale ranges shall be as specified. For meters that are not end-zero meters, the center and end-scale ranges shall be specified appropriately.

7.9.3 *Scale Divisions*—Unless otherwise specified, the value of each scale division shall be one, two, or five of the units measured or any decimal multiple or submultiple of these numbers.

7.9.3.1 *Linear Scales*—The total number of scale divisions shall be determined by dividing the total range by the smallest increment. For example; a 150-V scale with the smallest increment of 5 V is listed as having 30 scale divisions.

7.9.3.2 *Nonlinear Scales*—The total number of scale divisions shall be determined by dividing the total range by the smallest increment, although to avoid crowding scale marks, a portion of the scale shall not be marked. For example, a 100-A scale with the smallest increment of 2 A, but with no marks between 0 and 10 A, is listed as having 50 scale divisions.

7.9.4 *Scale Visibility*—The scale and characters shall be uniform visually in character brightness, legibility, and cleanliness of display with all elements of the meter illuminated. The entire meter scale shall be clearly visible from a distance of 1 m (3 ft) and from a viewing angle of 45° from normal; both vertically and horizontally. The scale visibility shall not deteriorate during the tests specified herein.

7.9.5 *Scale Markings*—Numerals, letters, and symbols shall be in accordance with Practice F 1166. Scale markings shall be as specified herein.

7.9.5.1 The orientation of numerals shall be tangential or erect for 90° scales, erect for 180 and 270° scaleplates, and erect for edgewise scales.

7.9.5.2 The sequence of scale divisions and numerals through the linear portion of the scale plate shall be uniform.

7.9.5.3 The scales shall begin and end with a numbered mark, including 0, when applicable.

7.9.5.4 There shall be not greater than five minor scale divisions between an intermediate or major scale division nor greater than three intermediate scale divisions between a major scale division.

7.9.5.5 The numbered markings shall be spaced uniformly and shall be expressed in the same units of measurement as



those of the end-scale marking. One, two, and five or decimal multiples thereof, shall be used when possible.

7.9.5.6 Scale division markings shall occupy not greater than 20 % of the space between a scale division mark and an adjacent mark.

## 8. Requirements

### 8.1 Electrical Requirements:

8.1.1 *Power Supply Voltage*—The meters shall operate from a voltage as specified as follows. A means of reverse voltage protection shall be provided:

- 5 ± 0.25 V direct current (Vdc)
- 28 ± 1.0 Vdc
- 115 ± 8.0 V alternating current (Vac)

8.1.2 *Signal Input*—The meters shall accept a digital or analog signal as specified.

8.1.3 *Insulation Resistance*—The insulation resistance shall be not less than 2 MΩ between the external terminals and the meter case.

8.1.4 *Alarm Set Points*—When specified, the meter shall be furnished with adjustable visible set points with form-C relay contact outputs for control of external devices such as remote alarms. The hysteresis of set points shall be not greater than 1.0 % of full scale.

8.1.4.1 *Setting*—Set points shall be programmed from the front of the meter. Set points should be set to a point on the bargraph as standard and use of the digital display for setting exact numerical values is an option.

### 8.2 Displays:

8.2.1 *Color Coding*—The LED color coding shall conform to Practice F 1166.

8.2.2 *Bargraph Display*—The bargraph display shall consist of segmented LED displays of the colors specified, which illuminate to produce a bar image equal to the corresponding scale value of the input. LED display color selection includes red, green, amber or use of tricolor LED display as an option.

8.2.3 *Power-On Indication*—The zero LED shall be continuously illuminated to serve as a “power on” and as a “zero reference” even in the absence of a signal input.

8.2.4 *Digital Display*—When specified, the meter shall include a red LED digital display that shall display continuously a specified range of values. The standard digital display shall match the bargraph display. An optional feature of different range values for the digital and bargraph displays shall be available when specified. The standard nominal character height shall be 4.88 mm (0.192 in.) for edgewise types with 2.4 mm (0.095 in.) as an option. The standard nominal character height shall be 10.5 mm (0.41 in.) for switchboard-type meters. The display type shall be seven segment as standard with dot matrix as an option.

8.2.5 *Intensity Control*—When specified, dimming controls shall be provided to maintain appropriate brightness, legibility, and operator dark adaptation level. These controls shall apply to all LED displays and, when used, dial illumination. The display luminance shall vary in direct proportion to ambient lighting, and the dial illumination in inverse proportion.

8.2.6 *Adjustments*—The meter shall contain provisions to adjust the zero-offset and full-scale range. The adjustment

devices shall be accessible from the rear of the meter when connected to the input signal and power supply sources.

8.2.7 *Set Point Visual Indication*—Visual indication of the set point locations shall be shown on the bargraph display by illuminating that LED segment corresponding to the set value when the input signal is lower than the set point value. When the input signal is greater than the set point value, the LED segment corresponding with the set point value is off. When the signal level is one LED segment greater or lower than the set point value, the LED corresponding to the set point value will flash once a second (1 Hz). When the signal level and the set point value are the same, the LED corresponding to the location will flash twice a second (2 Hz).

### 8.3 Performance Requirements:

8.3.1 *Zero Adjustment*—The meter shall include provision for zero adjustment by automatic or manual means. Manual means for zero adjustments shall provide for a minimum excursion of ±1 % of full scale about scale zero. The means shall be designed such that scale zero does not change as a result of any of the tests specified herein.

8.3.2 *Span Adjustment*—The meter shall include provision for span adjustment that provides for a full-scale adjustment above and below full scale of not less than 1.0 % of the rated full scale. The span adjuster shall be designed to prevent it from shaking loose and changing adjustment when subject to tests specified herein.

### 8.3.3 Accuracy:

8.3.3.1 *Bargraph Display*—The required accuracy of the meter bargraph display shall be established using the following equation:

$$\text{Bargraph display accuracy} = \frac{100}{[\text{number of LED elements}] - 1}$$

8.3.3.2 *Digital Display Accuracy*—The error of the digital display shall be not greater than 1.0 % for 3- and 3½-digit displays and shall be not greater than 0.1 % for displays with 4- and 4½-digit displays.

8.3.4 *Response Time*—The response time of the meter shall be not greater than 2 s for a zero to full-scale step input or full scale to zero step input signal.

### 8.3.5 Display Illuminance:

8.3.5.1 *Axial Illuminance*—The bargraph segment shall have a minimum illuminance of 60 mcd (0.6 mfc) at a distance of 200 mm (3.8 in.).

8.3.5.2 *Illuminance Variation*—The illuminance variation of the bargraph segments and the digital displays shall be not greater than 2.4 to 1.

8.3.6 *Chromaticity*—The chromaticity for LEDs shall be a follows:

8.3.6.1 Red shall be standard high efficiency with a dominant wavelength of 626 ± 2 nm.

8.3.6.2 Green shall be standard high efficiency with a dominant wavelength of 574 ± 2 nm.

8.3.6.3 Amber shall be standard high efficiency with a dominant wavelength of 585 ± 2 nm.

8.3.7 *Overload*—The meter shall be able to withstand a momentary overload of 200 % of full scale. The meter shall withstand a sustained overload of 20 % of full scale. During an overload, the digital display shall indicate the full-scale value

and all LED display elements shall illuminate except the most significant LED element shall flash. The meter shall meet the accuracy requirements of 8.3.3.

#### 8.4 *Environmental Requirements:*

8.4.1 *Temperature*—The meter shall operate in an ambient temperature range from 0 to +65°C, and shall withstand, without damage, a nonoperating (storage) temperature range of –55 to +85°C. The temperature error shall be not greater than the accuracy requirements of 8.3.3.

8.4.2 *Vibration*—The meters shall show no evidence of breakage, permanent deformation, or loosening of parts and shall retain their serviceability. The meter shall meet the accuracy requirements of 8.3.3.

8.4.3 *Salt Fog*—The meter shall show no evidence of salt penetration into the meter encasement nor evidence of corrosive effects, peeling, flaking, or color change in material.

8.4.4 *Temperature-Humidity Cycling*—The meter shall show no evidence of deterioration of parts or materials, loosening of finishes, physical distortion, corrosion of metals, moisture entrapment, or separation of bonded surfaces. The meter shall meet the accuracy requirements of 8.3.3.

### 9. Conformance and Production Tests

9.1 Conformance testing of a random sample may be requested by the purchaser to verify that selected performance characteristics specified in this standard have been incorporated in the meter design and have been maintained in the production bargraph meters supplied. These tests would not normally be performed unless specifically required. Production tests are routine tests performed on production units, or samples thereof, to ensure that basic requirements are met.

9.2 *Reference Conditions*—Reference conditions for testing meter performance shall be as follows:

9.2.1 Temperature: 23 ± 2°C.

9.2.2 Relative humidity: 40 to 60 %.

9.2.3 Atmospheric pressure: 575- to 800-mm mercury.

9.2.4 Position: on vertical panel.

9.2.5 External magnetic field: of the earth's field only.

9.2.6 Waveform (ac meter only): sinusoidal.

9.2.7 Warm-up time: 30 min.

9.2.8 Frequency (for ac meters other than frequency meters): rated ±3 %.

9.2.9 Voltage (for meters other than volunteers): rated value.

9.3 *Zero Adjust*—Meters shall be set to zero with use of the zero adjuster at the completion of each test.

9.4 *Number of Scale Readings*—Scale reading shall be taken at approximately six equidistant points on the scale including the end-scale points.

9.5 *Calibration*—A calibration inspection shall be conducted when specified in the individual test. It consists of applying known values of excitation to the meter, with not less than five equally spaced intervals over the full range of the meter and recording the correspondingly displayed values.

#### 9.6 *Conformance Tests:*

9.6.1 *Accuracy*—The accuracy shall be determined for the bargraph and digital displays under reference conditions (see 9.1) as follows:

9.6.1.1 Apply excitation to illuminate the exact end-scale LED mark and record the value of excitation.

9.6.1.2 Within 15 min, reduce the value of excitation to illuminate LEDs of not less than five other approximately equidistant scale marks including the zero mark. Measure and record the value of excitation at each scale mark.

9.6.1.3 The difference between the reference and measured conditions shall be calculated, in percentage of full scale, for each measured point. The accuracy of the meter shall be verified by using the greatest difference, in percentage, that was calculated.

9.6.2 *Response Time*—A photodetector with known response characteristics, having adequate sensitivity and resolution to respond to one element of the display, shall be positioned at the 80 % element of the meter display. The photodetector output shall be monitored with a storage oscilloscope or other suitable means. An input signal not less than 80 % of the meter range shall be applied to the meter input in less than 10 ms and held constant. This signal also shall be used to trigger the oscilloscope. Response time required for the display element at 80 % to illuminate shall be determined.

9.6.3 *Insulation Resistance*—The insulation resistance of the meter shall be determined by applying a test voltage ( $V_1$ ) between the external terminals and the meter case, through a 1000-Ω resistor. The type of current applied (ac or dc) is dependent upon the terminal's normally applied excitation. The level of  $V_1$  for circuits whose normally applied level is less than 50 V shall be 250 V. The level of  $V_1$  for circuits whose normal excitation is 50 V and higher shall be 10 times the normal excitation or 1000 Vdc (707 Vac rms), whichever is less. The current flowing through the terminals to ground is determined using the following:

$$\frac{E_M}{R_M} = I_M$$

where:

$E_M$  = Voltage drop across resistor;

$R_M$  = Resistance, 1000 Ω; and

$I_M$  = Current through terminals to ground.

The insulation resistance can be determined using  $I_M$  in the following equation:

$$\frac{V_T}{I_M} - 1000 \Omega = IR_M$$

where:

$IR_M$  = Insulation resistance of meter.

9.6.4 *Display Illuminance*—Illuminance shall be measured with instrumentation having a response that is within 2 % of the International Commission on Illumination (CIE) photopic curve over the specified color region.

9.6.4.1 *Axial Luminance*—The illuminance shall be measured with no ambient lighting, with all segments of the meter's display illuminated. All readings shall be taken to and at a distance of 200 mm from the plane of the front surface of the display elements, centered on the horizontal and vertical axes of the bargraph display. The luminance measurements shall be taken with a calibrated photometer and recorded.

9.6.4.2 *Luminance Variation*—Measure the illuminance of each segment on the center of its display surface in accordance with 9.6.4.1. Record the highest and the lowest readings

obtained. The luminance variation ( $D_L$ ) shall be determined using these readings in the following equation:

$$D_L = \frac{\text{highest reading}}{\text{lowest reading}}$$

9.6.5 *Chromaticity*—The bargraph meter chromaticity shall be determined by using one of the following three methods:

9.6.5.1 *Method I—Spectrophotometer*—Chromaticity shall be determined using a spectrophotometer, flat slab material of the same density and thickness of the shaped filter, and necessary calibration filters.

9.6.5.2 *Method II—Spectroradiometric*—Chromaticity shall be determined using a spectroradiometer, a completely illuminated meter, calibrated lamps of specific color temperature, and necessary calibration filters.

9.6.5.3 *Method III—Visual Comparator*—Chromaticity shall be determined by a color comparator, necessary high and low limit plastic or glass filters of known chromaticity, and calibrated light sources of specific color temperature.

9.6.6 *Overload:*

9.6.6.1 *Momentary Overload*—The voltage/current circuits of ac and dc meters shall be subjected to an application of 200 % of the rated full-scale value for 2 min. After 30 min at reference conditions (see 9.1) following the test, the meter shall be reset to zero and the change in indication shall be determined. The accuracy requirements of 8.3.3 shall be verified.

9.6.6.2 *Sustained Overload*—The meter shall be subjected for 8 h to an application of voltage/current 20 % greater than full-scale value. After 30 min at reference conditions (see 9.1) following the test, the meter shall be reset to zero and the change in indication shall be determined. The accuracy requirements of 8.3.3 shall be verified.

9.6.7 *Temperature*—The meter shall be tested, without alignment or adjustment, throughout the following temperature cycle:

9.6.7.1 Hold ambient temperature at  $0 \pm 2^\circ\text{C}$  for not less than 24 h.

9.6.7.2 Increase ambient temperature in steps of  $10^\circ$  each, at 30 min/step, until  $65 \pm 2^\circ\text{C}$  is reached, and hold at that temperature for not less than 4 h.

9.6.7.3 Reduce ambient temperature in steps of  $10^\circ$  each, at 30 min/step, until  $25 \pm 2^\circ\text{C}$  is reached, and hold at that temperature for not less than 4 h.

9.6.7.4 At each temperature plateau (0, 65, and  $25^\circ\text{C}$ ), a calibration cycle (see 9.5) shall be made. The temperature error is calculated as the change in indication caused by a temperature change of  $\pm 10^\circ\text{C}$  from the three temperature points (0, 65, and  $25^\circ\text{C}$ ).

9.6.8 *Vibration*—The meter shall be subjected to a simple harmonic motion in the X plane having an amplitude of 0.23 to 0.25 mm (0.46- to 0.50-mm total excursion), the frequency being varied uniformly between 500 and 2500 cycles/min for 20 min. The entire frequency range, from 500 to 2500 cycles/min and return to 500 cycles/min, shall be transversed at a rate of change of frequency of  $200 \pm 25$  cycles/min. During the test, an input equal to  $80 \pm 5$  % of the meter span shall be applied to the meter. After the test, the meter shall be examined visually and the accuracy verified in accordance with 9.6.1. Repeat for the Y and Z planes.

9.6.9 *Salt Fog*—The meter shall be tested in accordance with Practice B 117. The exposure time shall be 48 h followed by a 48-h drying period. The meter shall be examined visually after the test.

9.6.10 *Temperature/Humidity Cycling*—The meter shall be tested as specified in the following paragraphs. No adjustments during the test shall be made, other than the accessible controls employed for operation of the equipment.

9.6.10.1 *Conditioning*—To establish a reference condition, the meter shall be dried at a temperature not less than  $40^\circ\text{C}$  or greater than  $50^\circ\text{C}$  for not less than 2 h.

9.6.10.2 *Calibration Cycles*—Following the conditioning, a calibration cycle shall be performed as specified in 9.5 to indicate the satisfactory performance of the meter. This calibration cycle shall be conducted at  $25 \pm 5^\circ\text{C}$  and  $50 \pm 5$  % relative humidity. In addition, axial luminance shall be measured as specified in 9.6.4.1, except that only five segments of the display shall be measured. Throughout this test, the same five segments shall be monitored.

9.6.10.3 *Temperature Cycling*—Meters shall then be subjected to five 24-h cycles of temperature variation consisting of not less than 16 h at  $65 \pm 5^\circ\text{C}$  and approximately 8 h at  $25 \pm 5^\circ\text{C}$ . The relative humidity shall be maintained above a minimum of 95 % during the steady-state conditions. The transitions between temperatures shall be accomplished within 8-h period so that the time at the high temperature is not less than 16 h. Each transition shall be not greater than  $1\frac{1}{2}$  h if the meter remains in the chamber. If a two-chamber method is used, both chambers shall be stabilized at their appropriate settings before transferring the test units. The relative humidity need not be controlled during the transition periods. The chamber(s) used shall be proven able to maintain uniform temperature and humidity throughout the chamber.

9.6.10.4 *Measurements*—During the second cycle the measurements specified in 9.5 shall be taken at  $65 \pm 5^\circ\text{C}$  with the meter remaining in the chamber. The meter shall be energized for as brief a period as required to complete the measurements. A warm-up period shall be permitted in which previous tests indicate a definite period is required for the meter to attain thermal stability. After the five complete cycles, the measurements specified in 9.5 shall be performed at  $25 \pm 5^\circ\text{C}$  with the meter remaining in the chamber.

9.6.10.5 *Conditioning*—Upon completion of the tests, the meter shall remain inoperative for not less than 12 or greater than 24 h at a temperature at  $25 \pm 5^\circ\text{C}$  and  $50 \pm 5$  % relative humidity.

9.6.10.6 *Humidity Cycling*—The meter shall be operated continuously with an input equivalent to  $80 \pm 5$  % of the meter span in an ambient temperature of  $50 \pm 5^\circ\text{C}$  for a period of 8 h. The relative humidity shall be increased from  $50 \pm 5$  % to  $95 \pm 5$  % during the final 2 h.

9.6.10.7 *Measurements*—The meter's calibration shall be checked and recorded (see 9.5) at 2-h intervals, for a total of four checks. At each check, the same five input values shall be used.

9.6.11 *Workmanship*—Meters shall be manufactured in such a manner as to be uniform in quality. The interiors of the meters shall be free from metal filings, grease or oil, foreign material,



dust, or other loose particles that will affect the performance, serviceability, or appearance of the meter.

#### 9.7 *Production Tests:*

9.7.1 *Visual, Mechanical, and Workmanship Examination*—Meters shall be examined visually and mechanically to verify that materials, design, construction, physical dimensions, workmanship, and markings are as specified in this specification.

### 10. Certification Requirements

10.1 When specified in the purchase order or contract, a producer's or supplier's certification shall be furnished to the purchaser that the material was manufactured, sampled, tested, and inspected in accordance with this specification and has been found to meet the requirements. When specified in the purchase order or contract, a report of the test results shall be furnished.

### 11. Marking Requirements

11.1 *Meter Markings*—Each meter shall be provided with an identification plate. Plastic identification plates shall be used when attaching to other than a flat surface. Unless otherwise specified, the following shall be marked on the identification plates:

- 11.1.1 Manufacturer's name.
- 11.1.2 Manufacturer's type or model number.
- 11.1.3 Manufacturer's serial number.
- 11.1.4 Year of manufacture.
- 11.1.5 Country of origin.

### 12. Packaging Requirements

12.1 Product shall be packaged, boxed, crated, or wrapped to provide suitable protection during shipment and storage.

12.2 Preservation of meters shall be in accordance with Practice D 3951.

### 13. Quality Assurance

13.1 The manufacturer of the solid state bargraph meters shall maintain the quality of the meters that are designed, tested, and marked in accordance with this specification. At no time shall a meter be sold with this specification designation that does not meet the requirements herein.

### 14. Keywords

14.1 analog display; bargraph meter; digital display; edge-wise meter; electrical measurement; light-emitting diode; switchboard meter; solid state meter

## SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements are applicable to DoD procurements and shall apply only when specified by the purchaser in the contract or purchase order.

### S1. Referenced Documents

#### S1.1 *Military Specifications:*

MIL-S-901 Shock Tests, H.I. (High-Impact), Requirements for Shipboard Machinery, Equipment, and Systems<sup>5</sup>

MIL-C-24308 General Specification for Connectors, Electric, Rectangular, Nonenvironmental, Miniature, Polarized Shell, Rack and Panel<sup>5</sup>

#### S1.2 *Military Standards:*

MIL-STD-167-1 Mechanical Vibrations of Shipboard Equipment (Type I-Environmental and Type II-Internally Excited)<sup>5</sup>

MIL-STD-461 Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference<sup>5</sup>

MIL-STD-462 Measurement of Electromagnetic Interference Characteristics<sup>5</sup>

### S2. Dial Colors

S2.1 *Dial Colors*—For U.S. Navy applications, the dial color combination shall have black on a white background as standard (see 7.9.5). This color scheme optimizes visibility of meter in conditions of low ambient lighting, such as red-out locations.

### S3. Vibration Tests

S3.1 *Vibration Tests*—The meter shall be tested in accordance with MIL-STD-167-1, Type I. During the test, an input equal to  $80 \pm 5\%$  of the meter span shall be applied to the meter.

S3.2 *Examination After Vibration Tests*—The meters shall show no evidence of breakage, permanent deformation, or loosening of parts and shall retain their serviceability. The meter shall meet the accuracy requirements of 8.3.3.

### S4. Shock Tests

S4.1 *Shock Tests*—The meter shall be tested in accordance with MIL-S-901, Grade A, Class I, Type A. During the test, an input equal to  $80 \pm 5\%$  of the meter span shall be applied to the meter.

S4.2 *Examination After Shock Tests*—The meter shall show no evidence of screws, windows, or other parts being loose, cracked, or excessively damaged. The meter shall meet the accuracy requirements of 8.3.3.

### S5. Electromagnetic Interference (EMI) Requirements

S5.1 The meter shall meet the following requirements of MIL-STD-461 for surface ships and submarines: CE 101, CE 102, CS 101, CS 114, CS 116, RE 101, RE 102, RS 101, and

RS 103. The applicable electric field levels for requirements RS 103 shall be as follows:

Frequency	E-field level
10 kHz – 2 MHz	10 V/m
2 MHz – 30 MHz	50 V/m
30 MHz – 18 GHz	10 V/m

S5.2 *Electromagnetic Interference Tests*—The meter shall be tested in accordance with the applicable procedures in MIL-STD-462.

## S6. Terminals

S6.1 The meters shall be furnished with terminal connectors in accordance with MIL-C-24308. The connector pin assignments shall conform to S6.1.1 and S6.1.2

S6.1.1 *Digital Input*—The meter shall include two connectors, which shall be as follows:

S6.1.1.1 M24308/4-1

S6.1.1.2 M24308/4-3.

S6.1.2 *Analog Input*—The meter shall include a connector conforming to M24308/24-43 complete with jack screw hardware, M24308/26-1. The connector pins shall be as follows:

S6.1.2.1 Input signal (+).

S6.1.2.2 Input signal (–).

S6.1.2.3 LED test input signal, if applicable.

S6.1.2.4 LED test input return, if applicable.

S6.1.2.5 Power supply.

S6.1.2.6 Power supply.

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