INCH-POUND

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DETAIL SPECIFICATION

METERS, ELECTRICAL-INDICATING (SWITCHBOARD AND PORTABLE TYPES), GENERAL SPECIFICATION FOR

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

1. SCOPE

1.1 Scope. This specification covers switchboard and portable electrical-indicating voltmeters and ammeters, including prefixes micro, milli, and kilo.

1.2 Classification.

1.2.1 Types. The type designation of meters are in the following form as specified (see 3.1 and 6.2):

MR	**49**	**W**
Component (1.2.1.1)	Style (1.2.1.2)	Color scheme (1.2.1.3)

500	**DC**	**VV**	**H**
Full-scale value (1.2.1.4)	Kind of current (1.2.1.5)	Electrical units (1.2.1.6)	Special features (1.2.1.7)

1.2.1.1 Component. Meters covered by this specification are designated by the two-letter symbol "MR."

1.2.1.2 Style. The style is designated by a two-digit number which signifies the following characteristics:

1.2.1.2.1 First digit.

1.2.1.2.1.1 Switchboard meters. The first digit designates the nominal size and shape of flange on switchboard meters, as follows:

4 - 4½-inch rectangular flange
6 - 6-inch rectangular flange
9 - 8¾-inch rectangular flange

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1.2.1.2.1.2 Portable meters. The first digit designates the accuracy classification of portable meters, as follows:

5 - 0.5 percent for DC meters; 0.75 percent for AC meters

7 - 0.25 percent

1.2.1.2.2 Second digit.

1.2.1.2.2.1 Switchboard meters. The second digit designates the type of mounting and the nominal scale length in angular degrees, as follows:

8 - Flush mounting, 90 degree nominal scale

9 - Flush mounting, 250 degree nominal scale

1.2.1.2.2.2 Portable meters. The second digit designates the number of scale ranges, as follows:

1 - Single range

2 - Double range

3 - Triple range

1.2.1.3 Color scheme. The color scheme of the dial background, markings, and pointer is designated by a single letter, as follows:

B - Black dial background, white markings and pointer

W - White dial background, black markings and pointer

1.2.1.4 Full-scale value.

1.2.1.4.1 Single-range meters. The full-scale value of single-range meters with zero at left is represented by three figures designating the maximum number of units indicated; when the full-scale value is less than three figures, zeros are inserted at the left to fill out to three figures. Where the letter “R” is used in this group, between two figures, it represents a decimal point. Example: 1R5 represents 1.5

1.2.1.4.2 Multiple-range meters. The full-scale value of multiple-range meters with zero at left is represented as described for single-range meters in 1.2.1.4.1, except that the largest full-scale value is selected for the type designation. Other ranges for each multiple-range meter of a given type designation are as specified (see 3.1).

1.2.1.4.3 Offset zero. The full-scale deflection of zero-center or offset zero meters is indicated by two numbers designating the numerical value of the end-scale points, with a letter between them designating the decimal value of the numbers, as follows:

D - Tenths example: 5D5 represents 0.5-0-0.5

U - Units example: 1U9 represents 1-0-9

T - Tens example: 2T2 represents 20-0-20

H - Hundreds example: 5H5 represents 500-0-500

1.2.1.5 Kind of current. Two letters designate the kind of current for which the meter is designed, as follows:

AC - Alternating current (60 cycles per second, nominal frequency)
AD - Alternating current (60 cycles per second, nominal frequency), and direct current
AE - Alternating current (800 cycles per second, nominal frequency)
AF - Alternating current (400 cycles per second, nominal frequency)
AM - Alternating current (50 to 1,000 cycles per second)
AT - Alternating current (25 to 2,400 cycles per second)
DC - Direct current
RF - Radio frequency, conventional scale
RL - Radio frequency, linear expanded scale

1.2.1.6 Electrical units. Two letters designate the electrical units indicated by the meters, as follows:

UA - Microamperes
MA - Milliamperes
AA - Amperes
KA - Kiloamperes
MV - Millivolts
VV - Volts
KV - Kilovolts

1.2.1.7 Special features. A single letter designates a special feature, as follows:

H - High-impact, shock-resistant

1.2.1.8 Special meters. Meters having special characteristics such as adjusted resistance and special scale marks are identified by a National Stock Number.

1.2.1.9 Examples of type designation.

1.2.1.9.1 Switchboard meter. The type designation MR49W300DCVVH signifies:

a. MR - Electrical-indicating meter
b. 49 - 4½ -inch rectangular flange, switchboard meter, flush-mounting, 250 degree nominal scale
c. W - White dial background with black markings and black pointer
d. 300 - Zero left, full-scale value of 300
e. DC - Designed to be energized by direct current
f. VV - Electrical units in volts
g. H - High-impact, shock-resistant

1.2.1.9.2 Portable meter. The type designation MR72W020ADAA signifies:

a. MR - Electrical-indicating meter
b. 72 - 0.25 percent accuracy class portable meter with two ranges
c. W - White dial background with black markings and black pointer
d. 020 - Full-scale value of 20 for highest range
e. AD - Designed to be energized by 60-cycle alternating current and direct current
f. AA - Electrical units in amperes

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, or 5 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 documents cited in sections 3, 4, or 5 of this specification, whether or not they are listed.

2.2 Government documents.

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

FEDERAL SPECIFICATIONS

FF-S-200	-	Setscrews: Hexagon Socket and Spline Socket, Headless
FF-S-210	-	Setscrews: Square Head (Inch) and Slotted Headless (Inch and Metric)

FEDERAL STANDARDS

FED-STD-H28	-	Screw-Thread Standards for Federal Services

COMMERCIAL ITEM DESCRIPTIONS

A-A-55057	-	Panel, Wood/Wood Based Construction and Decorative

DEPARTMENT OF DEFENSE SPECIFICATIONS

MIL-PRF-29	-	Resistors, Fixed , Meter Multiplier, External (High Voltage, Ferrule Terminal Type)
MIL-S-901	-	Shock Tests, H.I. (High-Impact) Shipboard Machinery, Equipment, and Systems, Requirements for
MIL-E-917	-	Electrical Power Equipment Basic Requirements
MIL-DTL-1222	-	Studs, Bolts, Screws and Nuts for Applications Where a High Degree of Reliability is Required, General Specification for
MIL-I-1361	-	Instrument Auxiliaries, Electrical Measuring: Shunts, Resistors, and Transformers
MIL-L-10547	-	Liner, Case, and Sheet, Overwrap, Water Vaporproof or Waterproof, Flexible
MIL-DTL-15090	-	Enamel, Equipment, Light Gray, (Navy Formula No. 111)

(See supplement 1 for list of specification sheets.)

DEPARTMENT OF DEFENSE STANDARDS

MIL-STD-129	-	Military Marking for Shipment . and Storage
MIL-STD-130	-	Identification Marking of U.S. Military Property
MIL-STD-1916	-	DOD Preferred Methods for Acceptance of Product

(Copies of these documents are available online at http://assist.daps.dla.mil/quicksearch/ or http://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.

ASTM INTERNATIONAL

ASTM D709	-	Materials, Laminated Thermosetting (DoD adopted)
ASTM D1974	-	Fiberboard Boxes, Methods of Closing, Sealing and Reinforcing (DoD adopted)
ASTM D5118/D5118M	-	Fiberboard Shipping, Fabrication of (DoD adopted)
ASTM D5948	-	Compounds, Molding, Thermosetting (DoD adopted)
ASTM D6251	-	Standard Specification for Wood-Cleated Panelboard Shipping Boxes
ASTM D6880	-	Standard Specification for Wood Boxes

(Copies of these documents are available from ASTM International, 100 Barr Harbor Dr., PO Box C700, West Conshohocken, PA 19428-2959 or online at www.astm.org.)

3. REQUIREMENTS

3.1 Specification sheets. The individual item requirements shall be as specified herein and in accordance with the applicable specification sheet. In the event of any conflict between the requirements of this specification and the specification sheet, the former shall govern.

3.2 Qualification. Meters furnished under this specification shall be products that are authorized by the qualifying activity for listing on the applicable qualified products list before contract award (see 4.3 and 6.3).

3.3 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.

3.4 Material. The material for each part shall be as specified herein. When a definite material is not specified, a material shall be used which is adequate for the purpose intended and for meeting the requirements herein. Acceptance or approval of any constituent material shall not be construed as a guaranty of the acceptance of the finished product.

3.4.1 Plastic material.

3.4.1.1 Molded thermosetting. Molded thermosetting plastic material conforming to ASTM D5948 shall be used and shall be of the proper type for its intended use.

3.4.1.2 Laminated thermosetting. Laminated thermosetting plastic materials used for nameplates shall conform to ASTM D709.

3.4.2 Fume-emitting material. Material that emits deleterious or toxic fumes at 85 °C or lower shall not be used.

3.4.3 Coatings and finishes. Coatings and finishes which will melt, crack, chip, or scale as a result of tests specified in section 4 shall not be used.

3.5 Design and construction.

3.5.1 Balancing. The moving element shall be balanced by a means which will provide an easy method of rebalancing, such as threaded lock- or split-nuts, or a wire helix moving along a cross arm and counter-weight arm. The use of solder, or an adhesive such as shellac, to hold the balance weights or to function as a part of the balance weight, will not be acceptable.

3.5.2 Magnets. If laminated or multiple-piece magnets are used, the laminations or components shall be securely fastened together so that they will not separate or loosen as a result of tests specified herein.

3.5.3 Threaded parts. All threaded parts shall be in accordance with FED-STD-H28. Whenever practicable, all 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.

3.5.3.1 Bolts, nuts, and machine screws. All bolts, nuts, and machine screws shall conform to MIL-DTL-1222 or FF-S-200, and FF-S-210, as applicable.

3.5.3.2 Locking of screw-thread assemblies. When practicable, split-type lock washers or equivalent means shall be provided under all nuts.

3.6 Design and construction of component parts.

3.6.1 Cases. Meter cases shall be made of molded thermosetting plastic material, metal, or other material as specified herein. The cases shall be designed and constructed with close-fitting joints to minimize the entrance of moisture. The dimensions of switchboard meter cases shall be as specified in the specification sheets (see 3.1).

3.6.1.1 Portable meters. Portable meters shall be contained in a substantial case of hardwood, molded thermosetting plastic material, or metal. The case shall be provided with durable supporting feet and a suitable carrying handle. The container for meters of 0.25 percent accuracy class shall be provided with a hinged cover and a snap catch. Where an auxiliary carrying case is supplied for a portable meter, it shall be acceptable to the bureau or agency concerned.

3.6.1.2 Finish.

3.6.1.2.1 Switchboard. The portion of the case exposed to view from the front of the panel shall have a light gray finish in accordance with formula number 111, Class 2 of MIL-DTL-15090. No nickel or other bright trimmings shall be used. Metal cases shall be rendered resistant to corrosion prior to the application of the final gray finish.

3.6.1.2.2 Portable. All metal fitting and trimmings shall be protected against corrosion. Wooden cases shall have a durable semitransparent finish, such as varnish. Metal or plastic cases shall have a durable black finish on the exposed portion.

3.6.1.3 Certificate. Portable meters of 0.25 percent accuracy class shall be provided with a certificate covered with clear transparent plastic and attached to the case in a conspicuous place. The certificate shall be signed by a person authorized by the manufacturer and shall contain the following minimum information:

a. Manufacturer’s name
b. Type or model
c. Serial number
d. Date of calibration
e. Temperature correction
f. Accuracy classification
g. Resistance of each winding
h. Inductance of each winding of meters designed for both 60-cycle AC measurements (AD meters)

3.6.1.4 Window. Meters shall be provided with a window of glass and, when specified (see 6.2), exterior surfaces of windows shall be treated or coated to reduce glare. Windows shall be secured by clamps or other means, or cover and window may be one homogeneous unit.

3.6.1.4.1 Scale visibility.

3.6.1.4.1.1 Switchboard meters. The scale and window shall be so designed that when the dial is vertical the entire scale of the meter can be easily read at any angle up to 45 degrees below the horizontal centerline on the vertical centerline, and 20 degrees to either side of the vertical centerline on the horizontal centerline, with general

illumination coming from above and in front and at an angle 45 degrees from the horizontal centerline. Under these conditions, there shall be no objectionable shadow on the graduated scale.

3.6.1.4.1.2 Portable meters. The scale and window shall be so designed that the window will extend a minimum of ⅛ inch beyond all scale markings.

3.6.1.4.1.3 Window visual properties. When subjected to the visual conformance test (see 4.5.20), windows shall exhibit no detrimental visual effect which will unduly interfere with the reading of the scale or legend under normal lighting conditions.

3.6.2 Dial and pointer.

3.6.2.1 Dial. The dial shall be made of stiff material firmly secured to its mounting and readily removable. The dial shall be of such material and so secured as to insure freedom from warping, fading, or other deterioration during the test specified herein. Paper dials will be satisfactory only when adequately bonded to and backed by a metal support and when they meet all tests specified herein without fading, discoloring, warping, or other deterioration.

3.6.2.1.1 Scale.

3.6.2.1.1.1 Length. The scale length shall be as specified in the specification sheet (see 3.1).

3.6.2.1.1.2 Divisions. The value of each scale division shall, whenever practicable, be either: one, two, or five of the units measured or any decimal multiple or submultiples of these numbers. In the case of multiple-range meters or of meters for other specialized uses, exceptions to this requirement may be necessary, but shall be avoided when reasonably possible. The angle subtended by a scale division shall be not less than 0.5 degrees on portable meters, nor less than 1 degree on switchboard meters.

3.6.2.2 Pointer. The meter shall have a pointer so formed as to permit accurate readings at the usual distance from which the meter is viewed, and approximate readings up to the distance of legibility of the scale markings. The pointer shall be of rigid construction and suitable for the intended application, and shall not become damaged or distorted when subjected to any of the tests specified herein. The pointer shall not be affected or distorted by static electricity on the meter lens.

3.6.2.2.1 Pointer clearance (parallax). Where the meter is not provided with means for avoiding errors in reading due to parallax, the clearance between the pointer index and the graduated scale shall not exceed 0.10 inch, nor be less than 0.03 inch. Portable meters shall have a mirror on the dial near the scale and directly beneath the knife-edge portion of the pointer to reduce reading errors due to parallax.

3.6.3 Means of adjustment.

3.6.3.1 Accuracy adjustment. Meters shall be provided with practical shop means of adjustment to accuracy. Charging of the magnet and magnetically treating it to obtain accuracy, or adjusting the internal resistor, shall be considered as meeting this requirement.

3.6.3.2 Zero adjustment. Meters shall have a zero adjusting device accessible from the front of the case. The device shall be capable of being rotated through 360 degrees, without damage to the device or any part of the meter and without becoming inoperative or any parts becoming adrift or shall withstand 10 inch-ounces of torque without damage, distortion, or jamming. A device capable of being rotated through 360 degrees is preferred. Zero adjustment devices shall provide a range of adjustment above and below the zero mark on the scale of not less than 3 percent of the scale length (see 4.5.2).

3.6.4 Terminals and connections.

3.6.4.1 Portable meters. Binding-post terminals shall be so constructed that they cannot turn or twist in their mounting. Voltmeter terminals shall be insulated caps with no live parts exposed on cap nuts.

3.6.4.1.1 Selector switches. Range selector switches, when provided on multiple-range portable-type meters, shall be suitably indexed and marked so that the correct scale can be easily selected. Switches shall be designed to eliminate danger of electric shock to the operator. The switch shall have a life of 10,000 continuous no-load operations without impairing the operation of the meter sufficiently to cause it to exceed the rated accuracy (see 4.5.4.1.3).

3.6.4.2 Switchboard meters. Terminal studs shall be firmly anchored to the base of the meter in such a manner as to prevent turning or movement sufficient to cause damage to internal construction. Each terminal stud shall be furnished with the necessary nuts or screws, and washers.

3.6.4.2.1 Polarity. On all DC switchboard meters the left-hand terminal (looking at the rear of the meter in the normal mounting position) shall be the positive terminal (see 3.26.1.2).

3.6.4.2.2 Bonding. All permanent-magnet, moving-coil meters shall have the magnetic system and dial electrically connected to one terminal. Insulated cases having metallic bezel rings shall have this ring connected to the same terminal by means of a brush contact so that the mechanism can be readily withdrawn.

3.6.4.2.3 Connection diagrams. Meters having more than one circuit shall have a print showing the wiring diagram of connections with or without transformers, resistances, and reactances for three-phase, three-wire systems and two-phase, four-wire systems, together with instructions attached permanently or sufficiently secured to prevent loss during shipment.

3.6.5 Self-contained limitations. Unless otherwise specified (see 3.1), meters shall be self-contained for the following ranges:

Portable ammeters, AC and DC	80 amperes or less
Portable voltmeters, AC and DC	800 volts or less
Switchboard ammeters, 60-cycle AC, and DC	50 amperes or less
Switchboard ammeters, 400- and 800-cycle AC	no ranges
Switchboard voltmeters, DC	800 volts or less
Switchboard voltmeters, AC	600 volts or less

3.6.6 Mounting switchboard meters. Switchboard meters shall be mounted by means of mounting bolts or studs. The necessary mounting bolts (screws), nuts, and lock washers shall be supplied with each meter.

3.6.6.1 Four-and-one-half-inch meters. The 4½-inch meters shall mount on a panel drilled in accordance with the specified panel-drilling plan (see 3.1).

3.6.6.2 Six-inch meters. The 6-inch meters shall mount on a panel drilled in accordance with the specified panel-drilling plan (see 3.1), or shall be furnished with a suitable adapter to permit mounting without drilling additional holes.

3.7 External accessories. External shunts, shunt leads, resistors, and transformers shall be furnished when specified (see 6.2). External resistors used with DC meters shall conform to MIL-PRF-29; other external accessories shall conform to MIL-I-1361.

3.7.1 Calibration Potentiometer Single Meter Sensing. Meters shall be equipped with an internal or external mounted calibration potentiometer (or trim pot) to compensate the meter for up to 5 ohms of line lead resistance. The potentiometer shall be adjusted from 0 to 5 ohms, 10 turn and adjustable from the exterior of the meter.

3.7.2 Calibration Potentiometer Multiple Meter Sensing. In applications where one meter is used in conjunction with a selector switch to indicate several different readings, the meter's own calibration pot will be adjusted to 0 ohms. The equipment containing the meter shall provide a separate panel or circuit board containing individual meter trim pots to calibrate the meter for each position of the meter selector switch. The external trim pots shall be adjusted from 0 to 5 ohms, 10 turns and be easily accessible in the equipment. A separate trim pot shall be provided to calibrate the meter for each circuit to be indicated on the meter.

3.8 Calibration.

3.8.1 Position. Meters shall be calibrated in the position in which they are normally used, and shall meet the specified accuracy requirements in such position at the reference temperature (25 °C). The meter shall meet its specified accuracy requirements with the trim pot adjusted to the full 5 ohms of resistance at a reference temperature of 25 °C.

3.8.2 Mounting panel. Switchboard meters shall meet the specified accuracy requirements when mounted on a nonmagnetic panel and also on a magnetic-steel panel ⅛ inch thick.

3.8.3 Frequency. Alternating-current meters shall be calibrated at the following frequencies:

Kind of current	Frequency (c.p.s.)
AC	60
AD	60 and DC
RF	60
RL	60
AF	400
AE	800
AM	25, 60, 200, 400, 800, 1000
AT	(see 3.1)

3.9 Position influence (balance). When spring-controlled switchboard meters are tilted 60 degrees from their normal mounting position, in any direction, the pointer tip shall not deviate from the zero mark more than the amount specified (see 3.1 and 4.5.3).

3.10 Initial accuracy. At the reference temperature, the initial accuracy, expressed as a percentage of the full-scale value, shall be within the limits specified (see 3.1 and 4.5.4).

3.10.1 Direct-current reversal error. The change in indication, when reversed DC readings are taken on portable meters of 0.25 percent accuracy class designed for both AC and DC measurements (AD meters), shall not exceed the value specified (see 3.1 and 4.5.4.1.1).

3.10.2 Wave-form effect. The change in indication caused by an abnormal wave described in 4.5.4.1.2 shall not cause a change in indication greater than the amount specified (see 3.1). This test applies only to portable meters of 0.25 percent accuracy class designed for AC measurement.

3.11 Damping factor. When tested in accordance with 4.5.5, the damping factor shall not be less than the value specified (see 3.1).

3.12 Response time. When tested in accordance with 4.5.6, the response time shall not exceed the value specified (see 3.1).

3.13 Power consumption. The power consumption shall not exceed the value specified (see 3.1 and 4.5.7).

3.14 Frequency range. Alternating-current meters having a nominal frequency of 60 cycles per second shall operate over the range specified, and the change in indication from the reading at the nominal frequency shall not exceed the value specified (see 3.1 and 4.5.8).

3.15 Frequency influence. The frequency influence shall be not greater than the value specified (see 3.1 and 4.5.9).

3.16 External-field influence. Switchboard meters and 0.25 percent accuracy class portable meters shall have sufficient magnetic shielding so that the effect of an external magnetic field of 5 oersteds will not cause a change in indication greater than the value specified (see 3.1 and 4.5.10).

3.17 Heat effect at 65 °C. Meters shall indicate freely (see 6.6.9) during and after the test specified in 4.5.11. The heat effect at 65 °C (the difference between corresponding readings of steps 9 and 11 of table VI), and the permanent change in indication (the difference between corresponding readings of steps 1 and 13 of table VI), shall not exceed the value specified (see 3.1).

3.18 Temperature influence. The temperature influence shall not exceed the value specified (see 3.1 and 4.5.12).

3.19 Low-temperature exposure. During exposure to a temperature of 0 °C, meters shall indicate freely (see 6.6.9). The change in indication at the low temperature, and the permanent change in indication, shall not exceed the values specified (see 3.1 and 4.5.13).

3.20 Overload.

3.20.1 Momentary overload. The mechanism of AC and DC meters having current circuits shall be sufficiently rugged to withstand, without mechanical or thermal injury, a series of momentary overloads as specified in 4.5.14.1. As a result of this test, it shall not be necessary to make any repairs or adjustments other than resetting the pointer to zero, through the external zero-adjuster, and the permanent change in indication shall not exceed the value specified (see 3.1).

3.20.2 Sustained overload. When tested as specified in 4.5.14.2, the permanent change in indication, and the temporary and permanent zero shifts shall not exceed the value specified (see 3.1).

3.21 Dielectric stress. When tested in accordance with 4.5.15, meters shall withstand a voltage of 2,600 volts alternating current without damage or flashover.

3.22 Insulation resistance. The insulation resistance shall not be less than 20 megohms (see 4.5.16).

3.23 Vibration. When meters are tested in accordance with 4.5.17, no screws, bearings, pivots, or other parts shall be so loosened or damaged as to cause a change in indication greater than the value specified (see 3.1).

3.23.1 Friction effect. After completion of the vibration test specified in 4.5.17.1, the friction effect shall not exceed the value specified (see 3.1 and 4.5.17.1).

3.24 Humidity resistance. After completion of the humidity resistance test specified in 4.5.18, meters shall operate freely, and the permanent change in indication shall not exceed the value specified (see 3.1).

3.25 Shock (high-impact). When high-impact, shock-resistant meters are tested in accordance with 4.5.19, no screws, bearings, pivots, windows or other parts shall become loosened, cracked (except as specified hereinafter) or unduly damaged. Minor cracking or distortion of pivots will be permissible only when conformance to the post-shock performance has been demonstrated. Cracking of glass windows will be permissible only when readability of the complete scale is retained and no fragment has become dislodged. The permanent change in the indication based on calibration made after resetting the pointer to zero shall not exceed the value specified (see 3.1).

Note: The design of high-impact, shock-resistant meters shall be such that disassembly and proper reassembly prior to the shock test will not impair the shock-resistance of the meter.

3.26 Marking. Meters shall be permanently and legibly marked with the applicable information specified in 3.26.1 and 3.26.2.

3.26.1 Terminal identification.

3.26.1.1 Portable meters.

a. Polarity identification of DC meter terminals by a plus or minus sign on or near the applicable terminal

Note: The use of the minus sign is optional.

b. Range identification of multiple-range meters

c. Circuit identification of multiple-circuit meters

3.26.1.2 Switchboard meters. Polarity identification of DC meter terminals shall be indicated by a plus sign on or near the positive terminal (see 3.6.4.2.1).

3.26.2 Dials. Dial markings shall be sharply defined and visible from the front of the case. These markings shall not, however, be so conspicuous as to distract attention from the scale markings. Unless otherwise specified (see 3.1), the scale markings and numerals, and items b, c, and d below, when applicable, shall be marked on the dial; items a, and e through k shall be marked on the dial, on the front of the meter, or on an attached nameplate conforming to MIL-STD-130.

a. Type designation (see 1.2.1)

b. Designation of the quantity measured (e.g., Volts, amperes)

c. The words “direct current,” “alternating current”, or their abbreviations

d. Serial number on portable meters

e. Manufacturer’s name or trademark (or symbol), or both

f. Manufacturer’s type or model number, or both

g. The electrical quantity producing full-scale deflection when this differs from the full-scale value. Example: FS=50 mv

Note: On zero-center meters, replace “full-scale” with “end scale.” Example: ES=50 mv

h. External accessories as required. Example: Use with 50 mv shunt

i. Ratio of the appropriate current transformer, expressed as: 1000:5 or 1000/5 or 200:1 or 200/1

j. Ratio of the appropriate potential (voltage) transformer, expressed as: 3300:110 or 3300/110 or 30:1 or 30/1

k. Loop resistance of leads for external shunt of DC ammeter, when the lead resistance affects accuracy (see 6.2)

3.27 Workmanship. Meters shall be manufactured and processed in a careful and workmanlike manner in accordance with good design and sound practice. The interiors of meters will be free from metal fillings, grease or oil, foreign material, dust, or other loose particles which might interfere with the normal operation of the meters.

3.27.1 Soldering. Soldering shall be in accordance with MIL-E-917.

4. VERIFICATION

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

a. Qualification inspection (see 4.3)

b. Conformance inspection (see 4.4)

4.2 Test conditions and general instructions.

4.2.1 Atmospheric conditions.

4.2.1.1 Qualification tests. Unless otherwise specified herein, all qualification tests shall be made at ambient temperature of 23 °C to 27 °C, at existing barometric pressure, and with relative humidity of 40 to 60 percent.

4.2.1.2 Conformance inspections. Unless otherwise specified herein, all conformance inspections shall be performed at ambient temperature of 20 °C to 30 °C, at existing barometric pressure, and with relative humidity less than 80 percent.

4.2.2 Reference temperature. The reference temperature shall be 25 °C.

4.2.3 Position. Unless otherwise specified herein, tests performed on meters, including all tests requiring scale readings, shall be performed with the meter in the position in which it is normally used.

4.2.4 Examination of pivots and bearings. Examination of pivots and bearings for evidence of corrosion and damage from vibration, shock, and other tests, shall be made through a microscope having a magnification of 40 to 100 diameters.

4.2.5 Tapping. When taking meter readings, either the meter or its support shall be tapped lightly, except when ascertaining the effect of friction after the vibration test.

4.2.6 Parallax. The effect of parallax shall be avoided when taking meter readings.

4.2.7 Resetting to zero. Unless otherwise specified herein, meters provided with an external zero-adjuster may be set to zero at the completion of each test.

4.2.8 Thermal stability. For all tests, thermal stability shall be obtained at the specified temperature prior to reading the meters.

4.2.9 Number of scale readings.

4.2.9.1 Switchboard meters. Unless otherwise specified herein, readings on switchboard meters shall be taken at six approximately equidistant points on the scale, including the zero and end-scale readings.

4.2.9.2 Portable meters. On single-range portable meters, readings shall be taken at each numbered cardinal scale mark. On multiple-range portable meters, readings shall be taken at each numbered cardinal scale mark for one range only; on other ranges, readings shall be taken at five or more approximately equidistant points on the scale, including the zero and end-scale readings.

4.2.10 Standard meters. Standard meters shall be used to check the indications of meters submitted for test. Accuracies and tolerances specified are absolute, and readings of standard meters should be corrected before determining compliance.

4.3 Qualification inspection.

4.3.1 Samples. Sample meters submitted for qualification approval shall be representative of the manufacturer's normal production and shall be taken, preferably, from a current production lot. The type designation and number of specimens required to be submitted for each kind of meter shall be as specified in tables I and II, as applicable. Sample meters, which are used with external shunts, shall be supplied with shunt leads of 0.065±0.010-ohm resistance for switchboard meters and 0.026±0.005-ohm resistance for portable meters. Where 400- and 800-cycle meters are similar in basic construction to the submitted 60-cycle meter, only one additional specimen of each type is required. All qualification tests shall be performed on this specimen except the tests for external-field influence, vibration, humidity resistance, and shock (high-impact). If the basic design is different, a full number of specimens shall be submitted, and all qualification tests shall be performed.

4.3.2 Test routine. Sample meters shall be subjected to the applicable qualification tests shown in table III, in the order listed.

4.3.3 Failures.

4.3.3.1 Switchboard meters. One failure will be permitted on a sample of switchboard meters under the following conditions:

a. The failure is limited to one of the following tests:

(1) Position influence (balance)

(2) Initial accuracy

(3) Damping factor

(4) Response time

b. The magnitude of the failure is limited to 1½ times the specified tolerance for the initial-accuracy test, and 2 times the specified tolerance for the other three tests.

4.3.3.2 Portable meters. No failure will be permitted on portable meters.

4.4 Conformance inspection. Conformance inspection will be performed at the place of manufacture by the Government or under the direction of the Government.

4.4.1 Sampling procedure. At the discretion of the Government, conformance tests may be conducted by either of the following methods or a combination of both:

a. 100 percent inspection.

b. Statistical sampling and inspection in accordance with MIL-STD-1916. The classification of major and minor defects for visual and mechanical inspection shall be as specified in table V.

4.4.2 Test routine. Meters shall be subjected to the tests specified in table IV, in the order listed.

4.4.3 Rejected meters. Rejected meters shall be returned to the contractor. Rejected meters may be reworked, if possible, in such a manner as to remove all defects. Reworked meters shall be submitted for acceptance separately from newly-produced meters.

TABLE I. Samples for qualification test of switchboard meters.

Kind of meter		Specimens		Ranges covered (end scale)
		Type designation	Number required	
4½-inch, 250 degree nominal scale, high-impact, shock-resistant	DC voltmeters	MR49W300DCVVH	3	5 to 800 volts
	DC microammeter	MR49W050DCUAH	2	50 microamperes to 500 microamperes
	DC ammeters, self-contained	MR49W030DCAAH	3	1 milliampere to 50 amperes
	DC ammeters, external shunt	MR49W100DCAAH	3	Above 50 amperes
	AC voltmeters, 60 cycle[1/]	MR49W300ACVVH	3	150 to 600 volts
	AC ammeters, 60 cycle[1/]	MR49W005ACAAH	3	100 milliamperes to 14 kiloamperes
4½-inch, 250 degree nominal scale	DC voltmeters	MR49W300DCVV	2	5 to 800 volts
	DC ammeters, self-contained	MR49W030DCAA	2	1 milliampere to 50 amperes
	DC ammeters, external shunt	MR49W100DCAA	2	Above 50 amperes
	AC voltmeters, 60 cycle[1/]	MR49W300ACVV	2	150 to 600 volts
	AC ammeters, 60 cycle[1/]	MR49W005ACAA	2	100 milliamperes to 14 kiloamperes
6-inch, 90 degree nominal scale	DC voltmeters	MR68W300DCVV	2	5 to 800 volts
	DC ammeters, self-contained	MR68W030DCAA	2	1 milliampere to 50 amperes
	DC ammeters, external shunt	MR68W100DCAA	2	Above 50 amperes
	AC voltmeters, 60 cycle[1/]	MR68W300ACVV	2	150 to 600 volts
	AC ammeters, 60 cycle[1/]	MR68W005ACAA	2	1 milliamperes to 3 kiloamperes
8¾-inch 250 degree nominal scale, high-impact, shock-resistant	DC voltmeters	MR99W300DCVVH	3	5 to 800 volts
	DC microammeter	MR99W200DCUAH	3	200 microamperes to 1 milliampere
	DC ammeters, self-contained	MR99W030DCAAH	3	1 milliampere to 50 amperes
	DC ammeters, extent shunt	MR99W100DCAAN	3	Above 50 amperes

NOTE:

[1/] When approval is desired for 400- or 800-cycle meters, the range of the specimens submitted shall be the same as that specified for 60-cycle meters. The number of specimens required shall be in accordance with 4.3.1.

TABLE II. Samples for qualification tests of portable meters. [1/] [2/]

Kind of meter		Specimens		Ranges covered (end scale)
		Type designation	Number required	
0.25 percent accuracy class	AC-DC voltmeters			
	Single range	MR71W150ADVV	1	15 to 800 volts
	AC-DC ammeters			
	Single range	MR71W005ADAA	1	1 to 20 amperes
	Multiple range	MR71W020ADAA	1	5 to 20 amperes
	AC-DC milliammeters			
	Single range	MR71W050ADMA	1	50 to 500 milliamperes
	DC voltmeters			
	Single range	MR71W150DCVV	1	3 to 800 volts
	Multiple range	MR72W300DCVV	1	30 to 300 volts
	DC ammeters and millivoltmeters			
	Single range	MR71W020DCAA	1	1 to 20 amperes 50 to 500 millivolts
	Multiple range	MR73W300DCAA	1	3 amperes to 4 kiloamperes
0.75 percent accuracy class	AC voltmeters			
	Single range	MR51W300ACVV	1	15 to 800 volts
	Multiple range	MR53W750ACVV	1	150 to 750 volts
	AC milliammeters			
	Single range	MR51W015ACMA	1	10 to 500 milliamperes
	AC ammeters			
	Single range	MR51W005ACAA	1	1 to 50 amperes
	Multiple range	MR52W020ACAA	1	5 to 20 amperes
0.5 percent accuracy class	DC voltmeters			
	Single range	MR51W300DCVV	1	1 to 800 volts
	Multiple range	MR52W300DCVV	1	3 to 800 volts
	DC ammeters and millivoltmeters			
	Single range	MR51W010DCAA	1	10 milliamperes to 25 amperes
	Multiple range	MR53W300DCAA	1	3 amperes to 4 kiloamperes 150 millivolts

NOTES:

[1/] If a single-range meter is submitted, approval will cover single-range meters only, if a multiple-range meter is submitted, approval will cover both single- and multiple-range meters.

[2/] When approval is desired for AF, AE, AM, or AT meters, a specimen meter of the desired frequency and of the scale range designated for 60-cycle meters shall be submitted.

TABLE III. Qualification tests.

Test	Requirement paragraph	Test paragraph
Visual and mechanical inspection (without opening case)	(see table V)	4.5.1
Zero adjustment	3.6.3.2	3.6.3.2
Position influence (balance)	3.9	4.5.3
Initial accuracy	3.10	4.5.4
Damping factor	3.11	4.5.5
Response time	3.12	4.5.6
Power consumption	3.13	4.5.7
Frequency range	3.14	4.5.8
Frequency influence	3.15	4.5.9
External-field influence	3.16	4.5.10
Heat effect at 65 °C	3.17	4.5.11
Temperature influence	3.18	4.5.12
Low-temperature exposure	3.19	4.5.13
Overload	3.20	4.5.14
Dielectric stress	3.21	4.5.15
Insulation resistance	3.22	4.5.16
Vibration	3.23	4.5.17
Humidity resistance (1 specimen)	3.24	4.5.18
Shock (high-impact) (2 specimens)	3.25	4.5.19
Visual and mechanical inspection (external and internal)	(see table V)	4.5.1

Test	Requirement paragraph	Test paragraph
Visual and mechanical inspection (without opening case)	(see Table V)	4.5.1
Position influence (balance)	3.9	4.5.3
Initial accuracy	3.10	4.5.4.2
Dielectric stress	3.21	4.5.15
Insulation resistance	3.22	4.5.16
Damping factor	3.11	4.5.5
Response time	3.12	4.5.6
Power consumption	3.13	4.5.7

4.5 Test procedures.

4.5.1 Visual and mechanical inspection. Meters shall be inspected to determine compliance with table V.

TABLE V. Visual and mechanical inspection.

Requirement	Paragraph	Defect classification
Material	3.4 to 3.4.3, inclusive	Major
Design and construction	3.5	Minor
Cases	3.6.1 to 3.6.1.3 inclusive	Major
Dial and pointer	3.6.2	Minor
Means of adjustment	3.6.3	Minor
Terminals and connections	3.6.4	Minor
Mounting switchboard meters	3.6.6 to 3.6.6.2, inclusive	Major
Marking	3.26	Minor
Workmanship	3.27 and 3.27.1	Major
Window	3.6.1.4	Major
Scale visibility	3.6.1.4.1	Major

4.5.2 Zero adjustment. The range of zero adjustment above and below the zero mark shall be determined. A determination shall also be made as to whether the zero adjuster can be rotated through 360 degrees without damage to the device or any part of the meter or without becoming inoperative or any part becoming adrift. Zero adjustment devices not capable of rotation through 360 degrees shall be tested as follows: A screwdriver or similarly shaped tool shall be prepared by shaping the point for maximum snug engagement with the zero adjust device. This tool shall be mounted in a torque wrench which indicates torque of 10 inch-ounces. Ten ounces of torque shall be applied in both clockwise and counter-clockwise direction. Distortion, damage or jamming in either direction shall be cause for rejection.

4.5.3 Position influence (balance). The pointer shall be set to the center of the zero scale division with the meter in the normal operating position. The meter shall then be tilted 60 degrees from this position in any direction, and the deviation of the pointer noted (see 3.9).

4.5.4 Initial accuracy. Meters shall be checked for accuracy as specified in 4.5.4.1 or 4.5.4.2, as applicable.

4.5.4.1 Qualification test. After preliminary conditioning in the test circuit for 30 minutes at two-thirds scale deflection, readings shall be taken and compared with corresponding reading of the standard meter. The test shall be made with the meter at a temperature of 25 °C (see 3.10 and 4.2.9).

4.5.4.1.1 Direct-current reversal error. The change in indication produced by reversing the polarity of a DC source of energy shall be determined for portable meters of 0.25 percent accuracy class designed for both AC and DC measurement (AD meters). (see 3.10.1)

4.5.4.1.2 Wave-form effect. The change in indication produced by an abnormal wave form shall be determined on portable meters of 0.25 percent accuracy class designed for both AC and DC measurement (AD meters). For this test, a wave having the same rms value of a sine wave but a crest factor of not less than 2.4 shall be used. This wave shape can be obtained by combining, in equal parts and proper phase relationship, the fundamental and the third and fifth harmonics (see 3.10.2).

4.5.4.1.3 Selector-switch effect. After determining the initial accuracy, portable meters provided with a range selector switch shall have the range selector switch subjected to a life test of 10,000 continuous no-load operations. Each operation shall consist of making contact with each position, and returning to the starting position by reversing the direction of rotation. The rate of operation shall be between 0.25 and 1 second per contact position. Upon completion of the life test, the initial accuracy of the meter shall again be determined (see 3.6.4.1.1).

4.5.4.2 Conformance inspection. The conformance inspection of initial accuracy shall be performed under the test conditions specified in 4.2 without preliminary conditioning (see 3.10).

4.5.5 Damping factor. Electric power sufficient to produce momentary end-scale deflection shall be applied to the meter. The maximum momentary deflection shall be observed and recorded. After the pointer has come to rest, the steady deflection shall be observed and recorded. When making this test, the circuit resistance shall be not less than 100,000 ohms and such that no additional damping is added to the system. The damping factor shall be taken as the ratio of the steady deflection (in angular units) to the difference between the maximum momentary deflection and the steady deflection in angular units. Example: If the maximum momentary deflection is 90 angular degrees and the steady deflection is 75 angular degrees, the difference between the two is 15 degrees, and the damping factor (the ratio of 75 degrees to 15 degrees) is 5 degrees (see 3.11).

4.5.6 Response time. Steady electric power sufficient to produce momentary end-scale deflection shall be applied to the meter. The length of time, in seconds, required for the pointer to come to apparent rest shall be recorded. The pointer shall be considered as having come to apparent rest when it has obtained the actual point of rest within one-half the initial-accuracy requirement. The test shall be repeated five times, and the average length of time recorded for all measurements shall be considered as the response time of the meter (see 3.12).

4.5.7 Power consumption. The power consumption shall be measured at end-scale deflection and recorded in terms of current, voltage, voltamperes, or ohms, as applicable (see 3.13).

4.5.8 Frequency range. Unless otherwise specified (see 3.1), AC meters having a nominal frequency of 60 cycles per second shall be tested for satisfactory operation at the extreme operating frequencies specified (see 3.14).

4.5.9 Frequency influence. Alternating current meters shall be calibrated at nominal frequency, then at frequencies 10 percent above and 10 percent below the nominal frequency, and the change in indication determined (see 3.15).

4.5.10 External-field influence. This test applies to all switchboard meters and to 0.25 percent accuracy class portable meters. The meter shall be placed at the center of a four-turn coil, 50 centimeters in diameter, carrying a current of 50 amperes of the same kind and frequency as that which actuates the meter mechanism, and which produces a field of approximately 5 oersteds at the center of the coil. Readings shall be taken with the meter at various positions in the center of the field (see 3.16).

TABLE VI. Procedure for determining heat effect at 65 °C.

Cycle number	Period (hours)	Step number	Procedure
		1	Take initial reading at reference temperature.
1	16	2	Place meter in chamber at 65 °C and maintain that temperature for the remainder of that period.
		3	Read meter while at 65 °C at the end of step 2.
	8	4	Allow chamber and meter to cool down to the reference temperature during this period.
		5	Read meter while at reference temperature at the end of step 4.
2	16	6	Raise temperature of chamber and meter as rapidly as possible to 65 °C and maintain that temperature for the remainder of the period.
		7	Read meter while at 65 °C at the end of step 6.
	8	8	Allow chamber and meter to cool down to the reference temperature during this period.
		9	Read meter while at reference temperature at the end of step 8.
3	16	10	Raise temperature of chamber and meter as rapidly as possible to 65 °C and maintain that temperature for the remainder of the period.
		11	Read meter while at 65 °C at the end of step 10.
	8	12	Allow chamber and meter to cool down to be the reference temperature during this period.
		13	Read meter while at reference temperature at the end of step 12.

NOTE:

1. It is the intent to specify a test coil, which will produce a uniform field of approximately 5 oersteds through the case of the meter. Therefore, coils of other size are equally suitable if an equivalent electrical field is produced.

4.5.11 Heat effect at 65 °C. Meters shall be maintained at reference temperature for a sufficient time (not less than 2 hours) to attain thermal stability, and shall then be subjected to the three successive cycles of temperature change listed in table VI. During this test, meters shall indicate freely (see 6.6.9) at all parts of the scale (see 3.17).

4.5.12 Temperature influence. Meters shall be tested at temperatures 20 °C above and below the reference temperature. Reading shall be taken at not less than four points on the scale, one of which is at or near the maximum scale value and the temperature influence computed. The temperature influence shall be considered one-half the percentage change in indication caused by the 20 °C departures from the reference temperature. If the influences above and below the reference temperature are not equal, the greater value shall be considered the temperature influence (see 3.18).

4.5.13 Low-temperature exposure. Meters shall be exposed to a temperature of 0 °C for 16 hours, and at the end of the period meter readings shall be taken. It shall be observed whether or not the meter indicated freely at all parts of the scale while at 0 °C. Meters shall then be maintained at room temperature for sufficient time to attain thermal stability, and meter readings repeated. The permanent change in indication resulting from the low-temperature exposure shall be noted (see 3.19).

4.5.14 Overload.

4.5.14.1 Momentary overload. The current circuits of AC and DC meters shall be subjected to 10 applications of current equal to 10 times end-scale value. The current shall be applied nine times for a period of one-half second each time, with 1-minute intervals between successive applications, then followed by one application for a 5-second period (making a total of 10 applications during an elapsed period of 9 minutes, 9½ seconds), during which time current is applied for a total of 9½ seconds. (If the meter is provided with a voltage circuit, normal voltage shall be applied to the meter during the whole period of test.) After 1 hour at reference temperature following the above test, the pointer shall be reset to zero and the change in indication determined. This test should not be applied to external shunts (see 3.20.1).

4.5.14.2 Sustained overload. Meters shall be subjected for 8 hours to an application of energy 20 percent greater than end-scale value. Immediately after the load is withdrawn at the end of the 8-hour period, the temporary zero shift shall be determined. Sixteen hours after completion of the 8-hour overload period, the permanent zero shift shall be noted. The pointer shall then be set to zero and the permanent change in indication determined (see 3.20.2).

4.5.15 Dielectric stress. When performing this test, portable meters with nonmetallic cases shall be placed on a metallic platform; switchboard meters with nonmetallic cases shall be mounted on a metallic panel. All meters shall be subjected to a voltage of 2,600 volts rms applied between all external live parts of meter and:

a. The metallic platform or panel on which the meter is placed or mounted, or the meter case, if the case is metallic
b. The zero-adjuster, and range selector switch, when applicable
c. All exposed metal parts not a live part of the meter

The voltage shall be nominal 60 cycles per second in frequency and shall approximate, as closely as possible, a true sine wave in form. The voltage shall be applied continuously for a period of 60 seconds. The test voltage shall be measured by the voltmeter method whereby the measuring meter derives its voltage from the high-potential circuit, either directly or by means of a voltmeter coil placed in the testing transformer. To avoid voltage surges, the applied voltage shall be raised to its full value gradually, and upon completion of the 60-second test period shall be gradually reduced. The test shall be made using high-potential test prods having not less than ⅛-inch radius tips. Any damage or flash-over shall be noted (see 3.21).

4.5.16 Insulation resistance. Meters shall be placed on a metallic platform or mounted on a metallic panel as specified in 4.5.15. Using a potential of 500 volts direct current, the insulation resistance shall be determined between all external live parts and the metallic platform or panel on which the meter is placed or mounted, or the meter case, if the case is metallic (see 3.22).

Note: For conformance inspections of meters furnished with external accessories as an integral part, the complete meter (meter with accessories) shall be tested.

4.5.17 Vibration. Meters shall be mounted in various positions upon a vibration platform and subjected to vibration for a total period for 24 hours. The construction of the vibration platform shall be such as to give simple harmonic motion at a frequency of 400 cycles per minute, and with a maximum amplitude of 1/16-inch (⅛-inch maximum total excursion) at the horizontal centerline of the meter. The change in indication shall then be determined (see 3.23).

4.5.17.1 Friction effect. Upon completion of the vibration test, the friction effect shall be determined, as follows: Untapped ascending and descending reading shall be taken at five points distributed over the scale, using the same scale points for ascending and descending readings. The difference between corresponding ascending and descending readings as observed on the standard meter shall be determined (see 3.23.1).

4.5.18 Humidity resistance. Meter readings shall be taken at reference temperature. The meter shall then be place in a humidity chamber and kept for 6 hours at a temperature of 65 °C with relative humidity of 90 percent. Sufficient electrical energy shall be supplied to the meter to maintain two-thirds end-scale deflection. At the end of the 6-hour period, the heat shall be shut off and the meter de-energized. The meter shall then be permitted to cool for 18 hours in this atmosphere, the relative humidity of which rises as the temperature is reduced. (Precaution shall be taken to prevent dripping on meter.) A temperature of 35 °C or lower, but not less than 25 °C, shall be attained during the cooling period. The complete cycle shall then be repeated. Upon completion of the second cycle, the meter shall be removed from the humidity chamber and permitted to dry for a period of 24 hours at room temperature, with relative humidity less than 60 percent. Meter readings shall then be taken at reference temperature. The meter window shall then be removed and the meter, with the window removed, subjected to two additional cycles. The meter shall then be removed from the humidity chamber and permitted to dry for a period of 24 hours at room temperature, with relative humidity less than 60 percent. Meter readings shall then be taken at reference temperature. After the drying period, a maximum of 10 momentary end-scale deflections will be permitted prior to the final reading. Only one meter of the sample shall be subject to this test (see 3.24).

4.5.19 Shock (high-impact). High-impact, shock-resistant meters shall be tested in accordance with Type C of MIL-S-901 for lightweight equipment, when mounted on a plate as shown on Figure 6D of that specification. Two meters of the sample, which were not subjected to the humidity-resistance test, shall be used. During the test, one of the meters shall be energized to approximately one-half scale deflection. A total of nine blows shall be applied. Three blows shall be applied parallel to each of the three principal axis of the meters. The blows for each direction shall be with hammer drop heights of 1 foot, 3 feet, and 5 feet. The pointer shall be reset to zero after each blow. At the completion of the shock test, the meters shall be checked for calibration errors, then disassembled and carefully examined for damaged or misalignment of parts (see 3.25).

4.5.20 Visual inspection of windows. Meter dials shall be inspected through the installed window with the observer's line-of-sight on the centerline axis of the dial, between 18 and 24 inches from the dial. The illumination source shall be the diffused light from two 60-watt incandescent lamps placed behind and on either side of the observer, but no more than 3 feet from the meter dial. The sources shall be placed so as to eliminate shadows on the dial. For transparent windows, placement of light sources should minimize reflected glare. For anti-glare windows, placement of light sources should maximize reflected glare.

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.

6.1.1 Switchboard meters. Switchboard meters are intended for use in general application of electrical measurement including shipboard and land installations. High-impact, shock-resistant meters are preferred for shipboard use.

6.1.2 Portable meters. Portable meters are suitable for shipboard use as primary and secondary standards; however, they are intended for use in other applications in which the specified accuracy is sufficient for the required measurements. More accurate meters, generally designed as laboratory standards, are not covered by this specification.

6.2 Acquisition requirements. Acquisition documents should specify the following:

a. Title, number, and date of the specification.
b. Complete type designation or National Stock Number (see 1.2.1.8), and title, number, and date of applicable specification sheet. (see 1.2.1 and 3.1)
c. Adapters, if required. (see 3.6.6.2)
d. External accessories, if required. (see 3.7)
e. Loop resistance of leads for external shunt of DC ammeter. (see 3.26.2)
f. Packaging requirements. (see 5.1)
g. Requirement for treating or coating exterior surfaces of windows to reduce glare. (see 3.6.1.4)
h. When manufacturer may place red marks on meter dials at designated positions. (see 6.7.1)

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 Qualified Products List QPL No. 16034-59 whether or not such products have actually been so 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 Commander, Naval Sea Systems Command, ATTN: SEA 05M2, 1333 Isaac Hull Avenue, SE, Stop 5160, Washington Navy Yard DC 20376-5160 or emailed to CommandStandards@navy.mil.

6.4 Packing.

6.4.1 Domestic shipment and storage. Meters packaged as specified in 5.1 should be packed in wood-cleated fiberboard, wood-cleated plywood, nailed wood, or corrugated or solid fiberboard boxes conforming to ASTM D6251/D6251M, ASTM D6880, and ASTM D1974 and ASTM D5118/D5118M, respectively. Closures should be made in accordance with the applicable box specification. The gross weight should not exceed 45 pounds for fiberboard boxes and 150 pounds for plywood or wood boxes. Fiberboard having a minimum dry bursting strength (Mullen test) of less than 200 pounds should not be used.

6.4.2 Overseas shipment. Meters packaged as specified in 5.1 should be packed in wood-cleated fiberboard, wood-cleated plywood, nailed wood, or fiberboard boxes conforming to ASTM D6251/D6251M, ASTM D1974 and ASTM D5118/D5118M. Plywood should be Type B, condition I, conforming toA-A-55057. When the outer container of the unit package does not have water-resistance properties equivalent to those in ASTM D1974 and ASTM D5118/D5118M, shipping containers should have a case liner conforming to MIL-L-10547. Box closures should be as specified in the appendix of the applicable box specification. The gross weight should not exceed the limitations of the applicable specification for fiberboard boxes and 150 pounds for plywood boxes or wood boxes.

6.5 Marking. In addition to any special marking required by the contract or order, unit packages and exterior shipping containers should be marked in accordance with MIL-STD-129.

6.6 Definitions.

6.6.1 Accuracy. The accuracy is a number, which defines the limit of error, expressed as a percentage of full-scale value unless otherwise specified herein.

6.6.1.1 Accuracy rated. The rated accuracy is a number assigned by the manufacturer to designate the accuracy classification of the meter. This number, usually expressed as a percentage of full-scale value, is the limit which errors will not exceed when the meter is used under reference conditions.

6.6.2 Current circuit. The current circuit is that combination of conductors and windings of the meter which carries the current of the circuit in which a given electrical quantity is to be measured, or a definite fraction of that current, or a current dependent upon it.

6.6.3 Damping. Damping is the term applied to meter performances to denote the manner in which the pointer settles to its steady indication after a change in value of the measured quantity. The following general classes of damped motion are distinguished:

a. Periodic, in which the pointer oscillates about the final position before coming to rest.

b. Aperiodic, in which the pointer comes to rest without overshooting the rest position.

The point of change between periodic and a periodic damping is called critical damping.

Note: A meter is considered to be critically damped when overshoot is present but does not exceed an amount equal to one-half the initial-accuracy requirement of the meter (see 6.6.18).

6.6.4 Damping factor. The damping factor is the ratio of the steady deflection to the difference between maximum momentary deflection and steady deflection produced by a sudden application of constant electric power. All deflections are measure in angular degrees. In this specification, end-scale deflection is used as maximum momentary deflection.

Note: The damping factor of spring-controlled meters with their normal accessories, if any, is measured as the ratio of the steady deflection in angular units to the differences between angular maximum momentary deflection and the steady deflection produced by a sudden application of sufficient constant electric power to an unenergized meter to obtain end-scale deflection. This is the special case in which the deviation of the pointer from the position of equilibrium is the maximum value obtainable.

6.6.5 End scale value. The end-scale value of a meter is the value of the actuating electrical quantity which corresponds to end-scale indication. When zero is not at one end or at the electrical center of the scale, the larger value is taken.

6.6.6 Error and correction.

6.6.6.1 Error. The error of indication is the difference between the indication and the true value of the quantity measured. It is the quantity which, when algebraically subtracted from the indication, gives the true value. A positive error denotes that the indication of the meter is greater than the true value.

6.6.6.2 Correction. The correction has the same numerical value as the error of indication, but the opposite sign. It is the quantity which, when algebraically added to the indication, gives the true value. If the symbols T, I, E, and C represent the true value, the indication, the error, and the correction, respectively, the following equations hold:

$$E = I - T$$

$$C = T - I$$

EXAMPLE: A voltmeter indicates 112 volts when the voltage applied to its terminal is actually 110 volts.

THEN: Error = 112-110 = +2 volts

Correction = 110-112 = -2 volts

6.6.7 External-field influence. The external-field influence is defined as the percentage change in the indication which is caused solely by an external field of an intensity of 5 oersteds, produced by a current of the same kind and frequency as that on which the meter operates, with the most unfavorable phase and position of the external field.

6.6.8 Flush-mounting meter. In this specification, a flush-mounting meter is a meter designed so that, when mounted, the major portion of the meter will extend behind the mounting panel.

6.6.9 Free indication. Meters are considered as indicating freely if the pointer of the meter under test moves simultaneously with the pointer of the standard meter with which it is being compared, when the electrical energy supplied to both meters is gradually increased from zero to an amount sufficient to produce end-scale deflection of the meter under test.

6.6.10 Frequency influence. The frequency influence (in other than frequency meters) is defined as the percentage change in indication which is caused solely by a change of ±10 percent from the rated frequency.

6.6.11 Full-scale value. The full-scale value is equal to the largest value of the actuating electrical quantity which can be indicated on the scale; or, for meters having the zero between the ends of the scale, the full-scale values is the arithmetic sum of the values of the actuating electrical quantity corresponding to the two ends of the scale.

6.6.12 Magnetic shielding. Magnetic shielding is defined as limiting the effect of an external magnetic field of a designated strength to the value specified (see 3.1). Protection against magnetic fields may be inherent in the construction of the meter, or it may be obtained by the use of a physical magnetic shield.

6.6.13 Mechanism. The mechanism is the arrangement of the parts for producing and controlling the motion of the indicating means. It includes all the essential parts necessary to produce the results, but does not include the case, cover, dial, or any parts, such as series resistors or shunts, whose function is to adapt the meter to the quantity to be measured.

6.6.14 Meter, electrical-indicating. In this specification, an electrical-indicating meter is defined as a measuring device which measures the value of the quantity under observation. The term “meter” is used to include not only the meter proper but, in addition, any necessary apparatus, such as shunts, shunt leads, resistors, reactors, condensers, or instrument transformers.

6.6.14.1 Meter proper. The meter proper is the mechanism and the scale, built into the case, including all devices, such as resistors, shunts, and so forth, which are built into the case, or nonremovably attached to it.

6.6.14.2 Example. A 500-ampere direct-current ammeter consists of the meter proper, which may be thought of as essentially a millivoltmeter, together with a 500-ampere shunt and a pair of shunt leads.

6.6.15 Meter-rating. The meter-rating is a designation assigned by the manufacturer to indicate the operating limitations of the meter. The end-scale marking of a meter does not necessarily correspond to its rating.

6.6.16 Moving element. The moving element of a meter comprises those parts which move as a direct result of a variation in the electrical quantity which the meter is measuring.

6.6.17 Normal operating position. The normal operating position for meters covered by this specification is as follows:

a. Switchboard meters - mounted on a vertical panel.

b. Portable meters - placed on a horizontal support.

6.6.18 Overshoot. Overshoot is the ratio of the overtravel of pointer beyond its steady deflection to the change in steady deflection when the meter is suddenly energized with a new constant value of the measured quantity. The overtravel and deflection are determined in angular measure and the overshoot is usually expressed as a percentage.

6.6.19 Position influence (balance). The position influence is the maximum displacement of the pointer which is caused solely by a 60 degree inclination of the meter from normal operating position in the direction which produces the most unfavorable conditions as to position.

6.6.20 Power consumption. Power consumption is the electrical power required to produce end-scale deflection of the meter. Power consumption may be expressed in terms of units other than units of power.

6.6.21 Radio-frequency meter. In this specification, a meter designed to operate at 50 kilocycles per second or above is considered a radio-frequency meter.

6.6.22 Response time. This term denotes the rapidity with which the pointer comes to rest after a change of the measured quantity. It may be measured as the time, in seconds, for the pointer to come to apparent rest after a change in the value of measured quantity.

6.6.23 Scale, nominal. In this specification, switchboard meters are divided, on the basis of angular-scale length, into two groups designated as 90 degree and 250 degree nominal scale meters, respectively.

6.6.24 Scale division. A scale division is the increment between the centers of two consecutive scale marks.

Note: The number of scale marks is one more than the number of scale divisions. Example: 10 scale divisions require 11 scale marks.

6.6.24.1 Linear scales. The total number of scale divisions is determined by dividing the total range by the smallest increment. Example: A 150-volt scale with the smallest increment of 5 volts is listed as having 30 scale divisions.

6.6.24.2 Nonlinear scales. The total number of scale divisions is determined by dividing the total range by the smallest increment although, to avoid crowding scale marks, a portion of the scale may not be marked. Example: A 100-ampere scale with the smallest increment of 2 amperes, but with no marks between 0 and 10 amperes, is listed as having a 50 scale division.

6.6.25 Scale length. The scale length is the length of the path described by the tip of the pointer in moving from one end of the scale to the other. In the case of knife-edge pointers and others extending beyond the scale division marks, the pointer is considered as ending at the outer end of the shortest scale-division marks. For multiple-scale meters, the longest scale is used to determine the scale length.

6.6.26 Switchboard meter (distinguishing characteristics). A switchboard meter is magnetically shielded, 4 inches or larger in size, and unless otherwise specified (see 3.1), is of 1 percent accuracy.

6.6.27 Temperature influence. Temperature influence is the percentage change in the indication caused solely by a difference in ambient temperature of ±10 °C from the reference temperature.

6.6.28 Voltage circuit. The voltage circuit is that combination of conductors and windings of the meter to which is applied the voltage of the circuit in which a given electrical quantity is to be measured, or a definite fraction of that voltage, or a voltage or current dependent upon it.

6.6.29 Voltage influence. Voltage influence (in other than voltmeters) is the percentage change in the indication caused solely by a change of ±10 percent from the rated voltage.

6.7 Precautions. Attention of equipment designers and manufacturers is invited to the fact that sufficient space should be provided in equipment for mounting standard meters of the maximum depth specified (see 3.1) even though a shallower meter may be in the initial design.

6.7.1 Red mark on dial. When specified in the contract or order (see 6.2), the manufacturer may place red marks on meter dials at designated positions. There will be no change in the type of designation to distinguish such meters from those having normal markings; consequently, a meter supplied for a certain application may have a red mark at an undesired position. If this occurs, it is recommended that the user remove or cover the red mark by any convenient method, and make other red marks if desired.

6.8 Subject term (key word) listing.

High impact

Shock-resistant

6.9 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.

Custodians:
Army – CR
Navy – SH
Air Force – 99

Review Activities:
Army – AR, GL, MI
Navy − AS, EC, MC
Air Force – 11, 84

Preparing Activity:
Navy – SH
(Project 6625-N079-000)

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 Online database at http://assist.daps.dla.mil