Designation: F 2044 – 00

An American National Standard

Standard Specification for Liquid Level Indicating Equipment, Electrical[1]

This standard is issued under the fixed designation F 2044; 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 reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification covers the requirements for electrical liquid level indicating equipment for shipboard low pressure and high pressure tanks containing freshwater, feed water, potable water, seawater, wastewater, diesel fuel, lubricating oil, contaminated oil, refrigerants, JP fuels, and various other fluids. Application includes compensating tanks in which the equipment must locate the interface.

1.2 Each liquid level indicating equipment typically consists of the following components:

(a) One or more sensing devices;
(b) Flexible interconnections, if needed;
(c) Primary indicator panel assembly;
(d) Auxiliary indicator panel assembly, when required; and
(e) Portable indicator panel assembly, when required.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only. Where information is to be specified, it shall be stated in SI units.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.5 Special requirements for naval shipboard applications are included in the Supplement to this standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 3951 Practice for Commercial Packaging[2]

2.2 *ISO Standards:*

9001 Quality System Model for Quality Assurance in Design/Development, Production, Installation, and Servicing[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *hysteresis*—maximum difference in output, at any measurand value within the specified range, when the value is approached first with increasing and then with decreasing measurand.

3.1.2 *insulation resistance*—the resistance measured between insulated portions of a liquid level indicating equipment and between insulated portions of a liquid level indicating equipment and ground when a specified dc voltage is applied under specified conditions.

3.1.3 *output*—electrical or numerical quantity, produced by a liquid level indicating sensor or measurement system, that is a function of the applied measurand.

3.1.4 *pressure cycling*—the specified minimum number of specified periodic pressure changes over which a liquid level indicating sensor will operate and meet the specified performance.

3.1.5 *process medium*—the measured fluid (measurand) that comes in contact with the sensing element.

3.1.6 *repeatability*—ability of a liquid level indicating equipment to reproduce output readings when the same measurand value is applied to it consecutively, under the same conditions, and in the same direction.

3.1.7 *response*—the measured output of a liquid level indicating sensor to a specified change in measurand.

3.1.8 *signal conditioner*—an electronic device that makes the output signal from a sensor element compatible with a readout system.

3.1.9 *wetted parts*—liquid level indicating equipment components with at least one surface in direct contact with the process medium.

4. Designation

4.1 *Designation*—Most liquid level indicating equipment manufacturers use designations or systematic numbering or identifying codes.

4.2 *Design*—Liquid level indicating equipment typically consist of a sensing device that may or may not be in contact with the process medium, a transduction element that modifies the signal from the sensing device to produce an electrical output, and an indicator panel assembly to show the level of the medium being measured. Some parts of the sensing device may be hermetically sealed if those parts are sensitive to and may be exposed to moisture. The output cable must be securely fastened to the body of the sensing device. A variety of sensing

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[2] Available from the *Annual Book of ASTM Standards*, Vol 15.09.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

devices is used in liquid level indicating equipment. In the most common types of devices, sensing techniques such as admittance/impedance, magnetic float, static pressure, differential pressure, time domain reflectometry, radar, capacitive, resistance tape-type and ultrasonic are used. The function of the sensing device is to produce a measurable response to the admittance, impedance, differential pressure, reflected energy, capacitance, or resistance of the fluid being measured. The following is a brief introduction to the major level sensing technology design categories.

4.2.1 *Sensing Techniques*—The sensing device typically does not use any part of the tank structure as part of the sensing device.

4.2.1.1 *Admittance and Impedance*—The admittance and impedance sensing technique uses the apparent resistance to the current flow of an alternating current in the sensing device circuit or its reciprocal with respect to the level of the measured fluid in the tank.

4.2.1.2 *Magnetic Float*—The magnetic float sensing technique uses a float with embedded magnets to change the circuit status of the sensing device and produce an electrical signal proportional to the float's position with respect to the level of the measured fluid in the tank.

4.2.1.3 *Differential Pressure*—The differential pressure-sensing technique uses the pressure difference regardless of the ambient pressure to change the circuit status of the sensing device and produce an electrical signal proportional to the level of the measured fluid in the tank.

4.2.1.4 *Time Domain Reflectometry*—The time domain reflectometry sensing technique uses a high frequency electromagnetic wave transmitted along a transmission line, wire, cable, or rod to determine the level of the measured liquid(s) by detecting changes in and timing the reflected energy.

4.2.1.5 *Capacitive*—The capacitive-sensing technique uses the change in capacitance of the sensing device to produce an electrical signal proportional to the level of the measured fluid in the tank.

4.2.1.6 *Resistance Tape*—The resistance-tape-type sensing technique uses the change in circuit resistance in the sensing device to produce an electrical signal proportional to the level of the measured fluid in the tank.

4.2.1.7 *Static Pressure*—The static head technique measures the static (head) pressure caused by the measured liquid relative to the ambient pressure to change the circuit status of the sensing device and produce an electrical signal proportional to the level of the measured fluid in the tank.

4.2.1.8 *Radar*—The radar technique uses a high frequency electromagnetic wave transmitted through the air, including guided inside a hollow tube, to determine the level of the measured liquid(s) by detecting changes in and/or timing the reflected energy.

4.2.1.9 *Ultrasonic*—The ultrasonic technique uses high frequency sonic waves transmitted either through the air or in the liquid to be measured, to determine the measured liquid(s) level by detecting changes in and/or timing the reflected energy.

4.3 *Process Medium*—The following are the most common types of process media. The first column identifies fluids that are measured in the tank. The second column identifies the liquid or gas that interfaces with the measured fluid.

Fluid	Liquid or Gas
Contaminated fuel	air
Contaminated oil	compressed air
Fuel (diesel fuel, cargo fuel, gasoline)	compressed gas
Freshwater, potable water, feed water	Water
Hydraulic oil	steam
JP-5, JP fuels	seawater
Lubricating oil	wastewater
Refrigerants	
Synthetic oil	
Seawater	
Turbine oil	
Waste oil	
Wastewater, sanitary waste	

4.4 *Pressure Range*—The liquid level indicating equipment must be able to withstand the expected fluid pressures in the tank. Pressure range specification must take into account expected pressures to be encountered in differing tank sizes and fluid types for a particular sensor type.

4.5 *Display*—The display for liquid level indication is typically specified as analog, digital, or both.

5. Ordering Information

5.1 The purchaser shall provide the manufacturer with all of the pertinent application data shown in accordance with 5.2. If special application operating conditions exist that are not shown in the acquisition requirements, they shall also be described.

5.2 *Acquisition Requirements*—Acquisition documents must specify the following:

(a) Title, number, and date of this specification;
(b) Manufacturer's part number;
(c) Sensing technique;
(d) Application;
(e) Pressure range;
(f) Display requirements (see 4.5) and indication range;
(g) Indicator panel assembly mounting method;
(h) Indicator panel assembly requirements;
(i) System operating characteristics;
(j) Materials;
(k) Environmental requirements;
(l) Quantity of liquid level indicating equipment required;
(m) Size and weight restrictions (see 7.5);
(n) Critical service life requirements (see 8.1);
(o) Performance requirements (see 8.2);
(p) Special surface finish requirements (see 9.1);
(q) When certification is required (see Section 13);
(r) Special marking requirements (see Section 14);
(s) Special packaging or package marking requirements (see Section 15);
(t) When ISO 9001 quality assurance system is not required (see 16.1); and
(u) Special warranty requirements (see 16.2).

6. Materials and Manufacture

6.1 *Sensing Devices*—The materials for the sensing devices and wetted pans shall be selected for long-term compatibility (see 8.1) with the process medium (see 4.3).

6.2 *Material Inspection*—The manufacturer shall be responsible for ensuring that materials used are manufactured, examined, and tested in accordance with the specifications and standards as applicable.

7. Physical Properties

7.1 *Enclosure*—Unique or special enclosure requirements shall be specified in the acquisition requirements (see 5.2).

7.2 *Liquid Level Indicating Equipment Mounting*—Liquid level indicating equipment is commonly mounted using brackets or similar hardware.

7.3 *External Configuration*—The outline drawing shall show the configuration with dimensions in SI units (inch-pound units). The outline drawing shall include limiting dimensions for electrical connections if required. The outline drawing shall indicate the mounting method with hole size, center location, and other pertinent dimensions. Where threaded holes are used, thread specifications shall be provided.

7.4 *Electrical Connection*—Electrical flexible interconnections shall be provided with each liquid level indicating sensor as specified in the contract (see 5.1).

7.5 *Size and Weight*—The user may have intended applications in which size and weight are limited. Size and weight restrictions shall be specified in the acquisition requirements (see 5.2).

8. Performance Requirements

8.1 *Service Life*—The user may have a minimum specified service life requirement that may be critical. Critical service life requirements shall be specified in the acquisition requirements (see 5.2).

8.2 *Liquid Level Indicating Equipment Performance*—Performance tolerances are usually specified in percent of indicator full scale. Critical performance requirements shall be specified in the acquisition requirements (see 5.2). The following performance characteristics and environmental exposures may or may not be important to each user's intended application.

Accuracy
Response time
Repeatability
Hysteresis
Insulation resistance
Specific gravity
Fluid conductivity
Tank wall proximity
Inclination
Spike voltage
Salt spray
Pressure
Vibration
Shock
Enclosure
dc magnetic field
Electromagnetic interference (EMI)
Immersion
Supply line voltage and frequency variation

9. Workmanship, Finish, and Appearance

9.1 *Finish and Appearance*—Any special surface finish and appearance requirements shall be specified in the acquisition requirements (see 5.2).

10. Inspection

10.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

(a) First article tests (see 10.2) and

(b) Conformance tests (see 10.3).

10.2 *First Article Tests*—First article test requirements shall be specified, where applicable. First article test methods should be identified for each design and performance characteristic specified. Test report documentation requirements should also be specified.

10.3 *Conformance Tests*—Conformance testing is accomplished when first article tests were satisfied by a previous acquisition or the product has demonstrated reliability in similar applications. Conformance tests are usually less intensive than first article tests, often verifying that samples of a production lot meet a few critical performance requirements.

11. Number of Tests and Retests

11.1 *Test Specimen*—The number of test specimens to be subjected to first article tests shall be specified and should depend on the liquid level indicating equipment design. Generally, one liquid level indicating equipment of each type (that is, sensing technique, application, pressure range, display, and indication range) shall be subjected to first article testing.

12. Test Data

12.1 *Test Data*—Test data shall remain on file at the manufacturer's facility for review by the buyer upon request. It is recommended that test data be retained in the manufacturer's files for at least three years or a period of time acceptable to the buyer and manufacturer.

13. Certification

13.1 When specified in the acquisition requirements (see 5.2), the buyer shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met.

14. Product Marking

14.1 User specified product marking shall be listed in the acquisition requirements (see 5.2). The minimum data to be clearly marked on each liquid level indicating equipment shall include the following:

(a) Manufacturer's name,

(b) Manufacturer's part number,

(c) Serial number or lot number,

(d) Date of manufacture (not required if serial number is traceable to date of manufacture), and

(e) Excitation voltage.

15. Packaging and Package Marking

15.1 *Packaging of Product for Delivery*— Product should be packaged for shipment in accordance with Practice D 3951.

15.2 Any special packaging or package marking requirements for shipment or storage shall be identified in the acquisition requirements (see 5.2).

16. Quality Assurance

16.1 *Quality System*—A quality assurance system in accordance with ISO 9001 shall be maintained to control the quality of the product being supplied effectively, unless otherwise specified in the acquisition requirements (see 5.2).

16.2 *Responsibility for Warranty*—Unless otherwise specified, the manufacturer is responsible for the following:

(a) All materials used to produce a unit and

(b) Workmanship to produce the unit.

Special warranty requirements shall be specified in the acquisition requirements (see 5.2).

17. Keywords

17.1 level indicator; liquid level; sensing device; tank level

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements established for U.S. Naval shipboard application shall apply when specified in the contract or purchase order. When there is conflict between the standard F25(LLIE)M-99 and this supplement, the requirements of this supplement shall take precedence for equipment acquired by this supplement. This document supersedes MIL-L-23886, *Liquid Level Indicating Equipment (Electrical)*, for new ship construction.

LIQUID LEVEL INDICATING EQUIPMENT (ELECTRICAL)

S1. Scope

S1.1 This specification supplement covers the requirements for electrical liquid level indicating equipment for use in low pressure and high pressure tanks aboard naval ships containing freshwater, feed water, potable water, seawater, wastewater, diesel fuel, lubricating oil, contaminated oil, refrigerants, JP fuels, and various other fluids.

S1.2 The values stated in SI units are to be regarded as the standard. Inch-pound units are provided for information only. Where information is to be specified, it shall be stated in SI units.

S2. Reference Documents

S2.1 *ABS Rules:*

Rules for Building and Classing Steel Vessels[4]

S2.2 *ISO Standards:*

9001 Quality System—Model for Quality Assurance in Design/Development, Production, Installation, and Servicing[5]

S2.3 *Military Standards:*

MIL-C-17 Cables, Radio Frequency, Flexible, Coaxial[6]

MIL-C-915 Cable and Cord, Electrical, for Shipboard Use, General Specifications for[6]

MIL-C-24231 Connectors, Plugs, Receptacles, Adapters, Hull Inserts, and Hull Insert Plugs, Pressure-Proof, General Specification for

MIL-L-17331 Lubricating Oil, Steam Turbine and Gear, Moderate Service[6]

MIL-S-901 Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for[6]

MIL-S-16032 Switches and Detectors, Shipboard Alarm Systems[6]

MIL-STD-167-1 Mechanical Vibrations of Shipboard Equipment (Type I—Environmental and Type II—Internally Excited)[6]

MIL-STD-461 Electromagnetic Interference Characteristics of Subsystems and Equipment, Requirements for the Control of[6]

MIL-STD-1399 Section 070, Interface Standard for Shipboard Systems, D.C. Magnetic Field Environment[6]

MIL-STD-1399 Section 300, Interface Standard for Shipboard Systems, Electric Power, Alternating Current[6]

S2.4 *NEMA Standards:*

250 Enclosures for Electrical Equipment (1000 V Maximum)[7]

S3. Terminology

S3.1 Terminology is consistent with that of Section 3 and the referenced documents.

S4. Designation

S4.1 *Designation*—For this specification, liquid level indicating equipment designations shall be assigned as specified in S5.1 and listed in the format below:

Example: F25(LLIE)M-MF-SW/AR-LP-A-005/245/250

Specification	MF	SW/AR	LP	A	005/245/250
F25(LLIE)M	Sensing technique	Application	Pressure range	Display	Indication range
	S4.2	S4.3	S4.4	S4.5	S4.6

[4] Available from American Bureau of Shipping, 2 World Trade Center, 106th Floor, New York, NY 10048.

[5] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[6] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 119111–5094, Attn: NPODS.

[7] Available from NEMA, 1300 N. 17th St., Suite 1847, Rosslyn, VA 22209.

S4.2 *Sensing Technique*—The sensing technique shall be designated as follows:

AZ — Admittance/impedance
CA — Capacitive
DP — Differential pressure
MF — Magnetic float
RD — Radar
RT — Resistance tape type
TD — Time domain reflectometry
SP — Static pressure (head)
US — Ultrasonic

S4.3 *Application*—The fluid to be measured shall be designated as follows. The first two-letter designation identifies the fluid to be measured in the tank. The second two-letter designation identifies the liquid or gas that interfaces with the measured fluid.

Fluid	Liquid or Gas
CF — Contaminated fuel	AR — Air
CO — Contaminated oil	CA — Compressed air
FO — Fuel (diesel fuel, cargo fuel, gasoline)	CG — Compressed gas
FW — Freshwater, potable water, feed water	ST — Steam
HO — Hydraulic oil	SW — Seawater
JP — JP-5, JP fuels	WW — Wastewater
LO — Lubricating oil	
RF — Refrigerants	
SO — Synthetic oil	
SW — Seawater	
TO — Turbine oil	
WO — Waste oil	
WW — Wastewater, sanitary waste	

S4.4 *Pressure Range*—The pressure range under which the sensing device shall operate shall be designated as follows:

AP — Vacuum pressure of 749–mm mercury (29.5–in. mercury) to 138 kPa (20 psig) inclusive.
VP — Vacuum pressure of 749–mm mercury (29.5–in. mercury) to 689 kPa (100 psig) inclusive.
LP — From 0 kPa to 689 kPa (0 to 100 psig) inclusive.
HP — From 696 kPa (101 psig) to maximum pressure as specified (see S5.2).

S4.5 *Display*—The display shall be designated as follows:

A — Analog
D — Digital
C — Analog and digital

S4.6 *Indication Range*—The indication range shall be designated by three numbers, separated by a slash. Each number shall represent a height in millimetres above the bottom of the tank. The first number shall indicate where liquid level indication shall begin. The second number shall indicate where liquid level indication shall end. The third number shall indicate the total height of the tank.

S5. Ordering Information

S5.1 The buyer shall provide the manufacturer with all of the pertinent application data in accordance with S5.2. If special application operating conditions exist that are not in the acquisition requirements, they shall also be described.

S5.2 *Acquisition Requirements*—Acquisition documents shall specify the following:
(a) Title, number, and date of this specification;
(b) Part designation required (see S4.1);
(c) National Stock Number (NSN) if available;
(c) National Stock Number (NSN) if available;
(d) Quantity of liquid level indicating equipment required;
(e) If pressure range is HP, the maximum pressure required (see S4.4);
(f) If deviation requests are not required when departing from material guidance (see S6);
(g) If the maximum height of any individual component is other than 3048 mm (120 in.) or maximum weight of any individual component is other than 16 kg (35 lbs) (see S7.6);
(h) If primary indicator panel assembly is panel or bulkhead mounted (see S7.9);
(i) If more than one liquid level display is required for the primary indicator panel assembly (see S7.9);
(j) If volumetric accuracy is required (see S7.9.1);
(k) If a control circuit is required and whether settings are to be two high, two low, one high and one low, or two high and two low (see S7.9.2);
(l) If alarm lights are required on primary indicator panel assembly (see S7.9.3);
(m) If audible alarm and alarm acknowledge switch are required on primary indicator panel assembly (see S7.9.3);
(n) If a protective shield is required for primary indicator panel assembly (see S7.9.4);
(o) If auxiliary indicator panel assembly is required. Specify either panel or bulkhead mounted, and what is required in addition to a liquid level display (see S7.10);
(p) If portable indicator assembly is required (see S7.11);
(q) If epoxy coating is required (see S7.13);
(r) If special purpose equipment is not to be provided (see S7.14);
(s) If indicator dial is not to be furnished blank or if additional information is to be identified on the dial or if dials are to have other than black letters, numerals, and graduations on a white background (see S7.15.1);
(t) If red illumination is required for liquid level display (see S7.15.2);
(u) If audible signals are required for any remote station (see S7.16);
(v) If dc magnetic field strength requirement is other than 400 A/m (see S8.16 and S12.2.15);
(w) When first article tests are required (see S10.3);
(x) Sampling and acceptance numbers for Group A and Group B testing (see S11.1 and S11.3);
(y) If the inclination angle is other than 45° (see S12.2.8);
(z) Special product marking requirements (see S14);
(aa) Special packaging or package marking requirements (see S15);
(bb) When ISO 9001 quality assurance system is not required (see S16.1); and
(cc) Special warranty requirements (see S16.2).

S5.3 *First Article Tests*—When first article testing is required, the buyer should provide specific guidance to offerors whether the item(s) should be a preproduction sample, a first article sample, a first production item, a sample selected from the first production items, or a standard production item from the manufacturer's current inventory. The number of items to be tested in accordance with S10.4 should be specified. The buyer should include specific instructions in acquisition documents regarding arrangements for tests, approval of first article test results and time period for approval, and disposition of first

articles. Invitations for bids should provide that the buyer reserves the right to waive the requirement for samples for first article testing to those bidders offering a product which has been previously acquired or tested by the buyer; and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior buyer approval is presently appropriate for the pending contract. The manufacture of items before buyer approval should be specified as the responsibility of the manufacturer.

S6. Materials

S6.1 *General*—Toxic materials shall not be used in potable water applications.

S6.2 *Metals*—Unless otherwise specified herein, all metals used in the construction of liquid level indicating equipment shall be corrosion resistant or treated to provide corrosion resistance. Dissimilar metals shall not be used in contact with each other unless suitably finished to prevent electrolytic corrosion. The materials for wetted parts shall be selected for long-term compatibility (see S8.1) with the contacted fluid, liquid, or gas (see S4.3).

S6.3 *Flammable Materials*—Materials used in the construction of liquid level indicating equipment shall in the end configuration be noncombustible or fire retardant in the most hazardous of atmosphere, pressure, and temperature to be expected in the application. Fire retardance shall not be achieved by use of nonpermanent additives to the material.

S6.4 *Fungus-Resistant Materials*—Materials used in the construction of liquid level indicating equipment shall not support the growth of fungus.

S6.5 *Solvents, Adhesives, and Cleaning Agents*—When chemicals or cements are used in bonding of internal components, no degradation shall result during in-service use.

S7. Physical Properties

S7.1 *Configuration*—Each liquid level indicating equipment shall consist of the following components:

(a) One or more sensing devices,

(b) Flexible interconnections, if needed,

(c) Primary indicator panel assembly,

(d) Auxiliary indicator panel assembly, when required (see S5.2), and

(e) Portable indicator assembly, when required (see S5.2).

S7.2 *Magnetic Float Liquid Level Switches*—Magnetic float liquid level switches shall be in accordance with MIL-S-16032.

S7.3 *Microprocessors*—When microprocessors are used to perform processing and control functions, built-in test (BIT) shall be provided in the form of firmware residing in programmable read only memory. To assist troubleshooting, BIT shall indicate basic failure modes of the equipment such as power supply parameters out of tolerance.

S7.4 *Testability*—No mechanical or electrical disassembly shall be required for the purpose of obtaining access to test points or adjustments, except for removal of a cover plate.

S7.5 *Safety*—For JP, CF, CO, WO, and FO applications, the portions of the liquid level indicating equipment inside the tank shall be in accordance with the hazardous area requirements of ABS Rules for Building and Classing Steel Vessels, except flexible interconnections shall be in accordance with S7.8.

S7.6 *Size and Weight*—Unless otherwise specified (see S5.2), the maximum height of any individual component shall be 3048 mm (120 in.). Unless otherwise specified (see S5.2), the maximum weight of any individual component shall be 16 kg (35 lbs).

S7.7 *Interchangeability*—In no case shall parts be physically interchangeable or reversible unless such parts are also interchangeable or reversible with regard to function, performance, and strength.

S7.8 *Flexible Interconnections*—Electrical flexible interconnections, including tank penetration cables, shall have high pressure pin connections in accordance with MIL-C-24231 on high pressure tank penetrations. Flexible interconnections shall permit easy repair, replacement, substitution, or bypassing of sensing devices. No interconnection boxes or junction boxes shall be installed inside of any tank. Flexible interconnections shall be Type I or Type II as specified herein.

S7.8.1 *Type I Flexible Interconnections*—Type I flexible interconnections shall be used in FO, CF, CO, WO, and JP applications. For sensing techniques other than TD, the cable shall be shielded, water-blocked cable consisting of watertight primary conductors, insulated with crosslinked (XL) modified polyalkene and with an outer layer of XL-modified polyvinylidene fluoride. The primary conductors shall be water blocked and wrapped with polyester tape. The shield shall be tin-plated copper and water blocked and wrapped with another polyester tape layer. The cable jacket shall be XL-modified ethylene-tetrafluoroethylene copolymer. The final cable formulation shall meet the physical characteristics as specified in MIL-C-915. For TD sensing techniques, the cable shall be FEP-jacketed coax cable in accordance with MIL-C17/127.

S7.8.2 *Type II Flexible Interconnections*—Type II flexible interconnections shall be used in applications other than FO, CF, CO, WO, and JP applications. Type II flexible interconnections shall be of watertight flexing construction in accordance with MIL-C-915 and MIL-C-915/8, Type DSS, TSS, FSS, and 755. The cable outer jacket shall be butadiene copolymer with an acrylonitrile content of 40 ± 10 % by volume. The final cable formulation shall meet the physical characteristics (tensile strength, elongation, bending endurance, and so forth) as specified in MIL-C-915. For TD sensing techniques, the cable shall be FEP-jacketed coax cable in accordance with MIL-C-17/127.

S7.9 *Primary Indicator Panel Assembly*—The primary indicator panel assembly shall be as small and lightweight as practicable and arranged for bulkhead or panel mounting as specified (see S5.2). Unless otherwise specified (see S5.2), the primary indicator panel assembly shall provide only a single liquid level display. The primary indicator panel assembly shall consist of devices such as regulated power supply, signal conditioners, controls, and indicators required for proper operation. When specified (see S5.2), a control circuit to be used for actuating an external device, such as an alarm or pump, when liquid level reaches predetermined points shall be provided. Other functional components and parts not included in the sensing device assembly shall be contained within the panel enclosure. Where multiple displays are combined on a single primary indicator panel assembly, there shall be no interaction

between the individual tank liquid level indicating equipment circuits except that a common power supply and operational test device may be used.

S7.9.1 *Signal Conditioner*—The signal conditioner shall provide a continuous output signal from 0 to 200 µAdc, 4 to 20 mAdc, 0 to 10 Vdc, or 1 to 5 Vdc. The signal conditioner output shall be uninterrupted from empty to full or over that portion of the tank to be measured. Unless volumetric accuracy is specified (see S5.2), the output signal shall be proportional to the actual liquid level height in the tank. When volumetric accuracy is specified, the output of the signal conditioner shall be proportional to the actual liquid level volume in the tank, and the contracting activity will furnish the tank capacity curve. Volumetric accuracy shall not be accomplished by modifications to the indicator dial scale or display.

S7.9.2 *Control Circuit*—When specified (see S5.2), a control circuit shall be provided that has two (two high, two low, or one high and one low), or four (two high and two low) independently adjustable settings, each of which controls a two-pole double throw switching device with a contact rating of 1 A (inductive) at 115 V, 60 Hz.

S7.9.2.1 *Control Circuit Setpoints*—The high level control circuit setpoints shall be adjustable from 50 to 98 % of the indicated range. The low level control circuit setpoints shall be adjustable from 2 to 50 % of the indicated range. No mechanical or electrical disassembly shall be required to access the control circuit setpoint adjustments except for removal of a cover plate. A control circuit test means shall be provided to verify the alarm setpoints and control circuit operation.

S7.9.3 *Controls and Indicators*—The following controls and indicators shall be mounted on the front panel of the primary indicator panel assembly:
(a) Power-on light (white lens),
(b) Power-on switch,
(c) One or more liquid level displays,
(d) Operational test device,
(e) When required, alarm lights (see S5.2), and
(f) When required, audible alarm and alarm acknowledge switch (see S5.2). Multiposition switches and controls may be used to combine functions.

S7.9.4 *Protective Shield*—The protective shield, when required (see S5.2), shall be rigid, transparent, shatterproof, and positioned as close to the indicator as possible to protect the indicator from accidental damage. The protective shield shall not trap moisture and shall be easily removable.

S7.10 *Auxiliary Indicator Panel Assembly*—When required (see S5.2), the auxiliary panel enclosure shall be as small and lightweight as practicable and arranged for bulkhead or panel mounting as specified (see S5.2). Unless otherwise specified (see S5.2), only a liquid level display shall be mounted on the front panel. The liquid level display shall be of the same type as on the primary indicator panel assembly. In the event of failure of the auxiliary indicator panel assembly, a device shall be provided on the primary indicator panel assembly to allow isolation of the auxiliary indicator panel assembly. With the auxiliary indicator panel assembly isolated, the primary indicator panel assembly shall continue to operate as specified herein.

S7.11 *Portable Indicator Panel Assembly*—When required (see S5.2), the portable indicator panel assembly shall meet the requirements of the primary indicator panel assembly (see S7.9), except bulkhead or panel mounting provisions are not required.

S7.12 *Mounting*—Component mounting devices or brackets shall be supplied with the liquid level indicating equipment.

S7.13 *Coating*—For all seawater applications and when required (see S5.2), the stationary metallic parts of the liquid level indicating equipment which may come in contact with the fluid to be measured, excluding flexible interconnections, shall be powder epoxy coated.

S7.14 *Maintainability*—The liquid level indicating equipment shall facilitate assembly, disassembly, fault isolation, operational test (for example, setting or checking alarm setpoints and setting or checking full-scale meter deflection), and preventative maintenance without the aid of special tools or special purpose equipment. Unless otherwise specified (see S5.2), special purpose equipment required for initial setup, equipment change, or troubleshooting shall be provided with the liquid level indicating equipment. Functional pans shall be readily identifiable, accessible, and removable for replacement. If possible, all equipment components, excluding float when used, shall be maintainable outside the tank.

S7.15 *Liquid Level Display*—Liquid level displays shall be 0 to 200 µAdc, 4 to 20 mAdc, 0 to 10 Vdc, or 1 to 5 Vdc; high impact shock resistant; and watertight or sealed electrical indicating meter types in accordance with one of the following:
(a) 4½ in., 250° with nominal scale length meter;
(b) Panel mounted, edgewise meter;
(c) Digital bargraph-type panel meter with minimum 4-digit display and minimum 51–segment (101–segment preferred) analog display. Light-emitting diode type preferred; and
(d) Digital panel display with 3½ digits graduated 0 to 100 % only. Light-emitting diode type preferred.

S7.15.1 *Dials*—Unless otherwise specified (see S5.2), liquid level display dials shall be furnished blank, except for minimum and maximum travel points. The dial shall be readily removable and replaceable from the front of the liquid level display without disturbing the pointer or other parts of the liquid level display. The dial surface shall be suitable for marking by an installing activity after the liquid level indicating equipment has been calibrated to a particular tank. When graduations are specified, they shall extend uniformly over the full range of the liquid level display and shall be multiples of 1, 2, 5, 10, 20, 50, and so forth. Multiples of any other numbers or fractions are not permitted. The minimum number of graduations per dial shall be 24 and the maximum number of graduations shall be 200. Dials shall begin and end with a numbered graduation. Markings such as “O” and “F” shall not be used. When required (see S5.2), additional information shall be identified on the dial as specified by the contracting activity. Unless otherwise specified (see S5.2), dials shall have black letters, numerals, and graduations on a white background. The indicator pointer shall be black.

S7.15.2 *Red Illumination*—When red illumination is specified (see S5.2), the primary indicator shall have white letters, numerals, and graduations on a black background and shall

contain internal red illumination. The letters, numerals, and graduations shall appear white under ambient white light and red under ambient and internal red light. The indicator pointer shall be either red illuminated or silhouetted against the dial. Red illuminated dials shall be readable in all levels of incident illumination up to 0.3 lux. The lighting circuit shall be ungrounded and shall be energized from a 6-V supply with separate external terminals.

S7.15.3 *Display Visibility*—The display shall be clearly visible from a distance of 3 ft and from a viewing angle of 45° from normal, both vertically and horizontally.

S7.16 *Audible Signals*—When audible signals are required for any remote station (see S5.2), the audible signal shall be actuated by the signal conditioner output or a control circuit adjusted to a predetermined level (see S7.9.1 and S7.9.2).

S8. Performance Requirements

S8.1 *Service Life*—Electrical liquid level indicating equipment shall be constructed for a life of 25 years of operation.

S8.2 *Sensing Device Operation*—The sensing device shall not use any part of the tank structure as part of the sensing device.

S8.3. *Accuracy*

S8.31 *Liquid Level Indicating Equipment Accuracy*—Liquid level indicating equipment accuracy shall be as follows:
(a) Actual liquid level as "height in the tank" or "volume in the tank" (volumetric accuracy), whichever is specified in S5.2, shall be within ±3 % of full scale and
(b) Repeatability of the indicators shall be within ±1 % of full scale at any point on the scale.

S8.3.2 *Control Circuit*—Accuracy of adjustable control circuit setpoints shall be as follows:
(a) Hysteresis of dead band make and break of the control function when operated through down and up cycles shall not exceed ±3 % including instrument hysteresis and dead band and
(b) Repeatability of the control point contact shall be within ±1 % of full scale.

S8.4 *Response Time*

S8.4.1 *Indication Response Time*—Liquid level indicating equipment shall have an indication response time of 0.5 s or less for liquid level change rates up to 1 in./s. Indication response time is defined as the time difference between when a liquid achieves a specified level and when the liquid level display indicates that specified level within the accuracy requirements of S8.3.

S8.4.2 *Control Circuit Response Time*—Control circuit response time shall be adjustable and shall have a minimum control circuit response time of 0.5 s and a maximum control circuit response time of 20 s. The indication response time shall be in accordance with S8.4.1 regardless of control circuit response time setting. Control circuit response time is defined as the time difference between when a liquid reaches a setpoint level and when the control circuit activates or deactivates the switching device associated with that setpoint level. Accuracy shall be in accordance with S8.3.

S8.5 *Insulation Resistance*—The liquid level indicating equipment insulation resistance shall be not less than 10 MΩ. Accuracy shall be in accordance with S8.3 after measurement of insulation resistance.

S8.6 *Specific Gravity*—For applications in which the fluid is FO, CO, WO, CF, or JP, accuracy shall be in accordance with S8.3 when subjected to changes in specific gravity. Manual adjustments shall not be permitted or required to obtain accuracy.

S8.7 *Fluid Conductivity*—For applications in which water of any type is present, accuracy shall be in accordance with S8.3 when the water conductivity is in the range of 3 to 10 000 µS/cm. Manual adjustments shall not be permitted or required to obtain accuracy.

S8.8 *Tank Wall Proximity*—Accuracy shall be in accordance with S8.3 when the distance from the sensing device to the tank walls is reduced.

S8.9 *Inclination*—Accuracy shall be in accordance with S8.3 when the liquid level indicating equipment is inclined. Differential pressure sensing devices with ranges less than 20 in. of water may compensate for hydrostatic pressure changes created by the inclined geometry.

S8.10 *Spike Voltage*—Accuracy shall be in accordance with S8.3 after spike voltage is applied.

S8.11 *Accelerated Life (Endurance)*—The liquid level indicating equipment shall withstand the effects of the accelerated life test. The temperature range shall be 0 to 60°C except for ST (steam) applications in which the temperature range shall be 0 to 100°C. Performance shall be in accordance with S8.3 throughout the test. After completion of the test and cleaning, the base metal shall not be visible through the finish nor shall there be any evidence of blistering, softening, separation from the base metal, corrosion, or other coating failures. Flexible interconnections shall not exhibit any signs of deterioration nor corrosion of connector pins and housings. Upon completion of the accelerated life tests, accuracy and response time shall be in accordance with S8.3 and S8.4.

S8.11.1 *Power Supply*—The power supply shall be compatible with Type I power input as specified in MIL-STD-1399, Section 300. Nominal power input voltage and frequency shall be 115 V, 60 Hz, single phase. Changes in input voltage and frequency within ±5 % of nominal shall have no deleterious effect on the power supply. Accuracy shall be in accordance with S8.3.

S8.12 *Enclosure*—Liquid level indicating equipment to be installed partially or totally outside the tank shall meet all test criteria in NEMA Standard 250 for Type 4X enclosures. Portable liquid level indicating equipment shall meet all test criteria in NEMA Standard 250 for Type 6 enclosures. Operation shall be in accordance with S8.3.

S8.13 *Pressure*—Sensing devices that may be exposed to seawater or the fluid being measured, complete with entrance fittings and interconnection fittings, shall withstand the pressure test without physical or electrical damage and without any leakage or signs of leakage around any of the fittings. Flexible interconnections shall show no evidence of liquid intrusion or evidence of mechanical or electrical damage. Accuracy of all readings shall be in accordance with S8.3 throughout the test and for the postinspection reference measurement.

S8.14 *Vibration*—Liquid level indicating equipment shall show no evidence of mechanical or electrical damage or loosening of pans when subjected to the vibration test. Operating controls shall not change status, and there shall be no transfer of switch contacts during, or as a result of, the vibration test. Accuracy shall be in accordance with S8.3.

S8.15 *Shock*—Liquid level indicating equipment shall show no evidence of mechanical or electrical damage or loosening of pans as a result of shock tests. Operating controls shall not change status, and there shall be no transfer of switch contacts as a result of shock tests. Accuracy shall be in accordance with S8.3.

S8.16 *DC Magnetic Field*—Unless otherwise specified (see S5.2), liquid level indicating equipment shall meet the 400-A/m dc magnetic field environment requirement of MIL-STD-1399, Section 070, Part 1. Accuracy shall be in accordance with S8.3.

S8.17 *Electromagnetic Interference*—The liquid level indicating equipment shall meet the requirements of Table II of MIL-STD-461, except as modified below:

CE101—The test signal shall be applied only to the ac power leads of the test sample.

CE 102—The test signal shall be applied only to the ac power leads of the test sample.

CS114—Only limit Curve #2 shall apply with the frequency range limited to 10 kHz to 30 MHz.

RE101—Only the limit curve for 50 cm shall apply.

RS103—The frequency range shall be limited to 10 kHz to 18 GHz with an electric field strength test level of 10 V/m.

Accuracy shall be in accordance with S8.3.

S8.18 *Flexible Interconnection*—Type I cables shall resist swelling and show no evidence of liquid intrusion or evidence of mechanical or electrical damage after immersion testing in JP-5. Removable flexible interconnections shall meet the insulation resistance test requirements of S8.5 after completion of immersion testing.

S9. Workmanship, Finish, and Appearance

S9.1 After fabrication, parts and assembled equipment shall be cleaned of smudges; loose, spattered, or excess solder; weld metal; metal chips and mold release agents; or any other foreign material that might detract from the intended operation, function, or appearance of the equipment. Wires and cables shall be positioned or protected to avoid contact with rough or irregular surfaces and sharp edges and to avoid damage to conductors or adjacent parts. There shall be no evidence of burns, abrading, or pinch marks in wire or cable insulation that could cause short circuits or leakage. The clearance between wires or cables and heat generating parts shall be sufficient to minimize deterioration of the wires or cables.

S10. Inspection

S10.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

(a) First article tests (see S10.2) and

(b) Conformance tests (see S10.3).

S10.2 *First Article Test*—First article tests shall be performed before production. First article tests shall be performed on samples that have been produced with equipment and procedures normally used in production. First article tests shall consist of the tests specified in Table S10.1. Failure of any liquid level indicating equipment to meet the requirements of this specification shall be cause for rejection.

S10.2.1 *Order of First Article Tests*—With the exception of the immersion test which may be performed at any time, the test specimens (liquid level indicating equipment) shall be subjected to the tests specified in Table S10.1 in the order listed. Any deviation in the test order shall first be approved by the buyer.

S10.3 *Conformance Tests*—Liquid level indicating equipment samples in each lot offered for delivery shall be subjected to the tests listed in Table S10.2 and shall be conducted in the order listed. Failure of any liquid level indicating equipment to meet the requirements of this specification shall be cause for rejection.

TABLE S10.1 First Article Tests

Test	Method	Requirement
Accuracy	S12.2.2	S8.3
Response time	S12.2.3	S8.4
Insulation resistance	S12.2.4	S8.5
Specific gravity	S12.2.5	S8.6
Fluid conductivity	S12.2.6	S8.7
Tank wall proximity	S12.2.7	S8.8
Inclination	S12.2.8	S8.9
Spike voltage	S12.2.9	S8.10
Accelerated life	S12.2.10	S8.11
Enclosure	S12.2.11	S8.12
Pressure	S12.2.12	S8.13
Vibration	S12.2.13	S8.14
Shock	S12.2.14	S8.15
dc magnetic field	S12.2.15	S8.16
Electromagnetic interference	S12.2.16	S8.17
Immersion	S12.2.17	S8.18

TABLE S10.2 Conformance Tests

Test	Method	Requirement
Group A		
General examination	S10.4	S1.6 and S1.7
Insulation resistance	S12.2.4	S8.5
Group B		
Accuracy	S12.2.2	S8.3
Supply line voltage and frequency variation	S12.2.18	S8.11.1

S10.4 *General Examination*—Each sample equipment shall be subjected to a general examination to ascertain that the material, parts, testability, input connectors and color code, size and weight, accessibility, workmanship, design, proper cable harness dress, creepage and clearance distances, safety requirements, and treatment for prevention of corrosion are in conformance with this specification. The fit of parts shall be observed with particular reference to the interchangeability of such parts as are likely to require replacement during the normal service life of the equipment. Examination shall also check all controls, adjustments, displays, indicators, liquid level indicating equipment description, mounting devices, signal conditioner, operation, control circuit (including failsafe design), primary indicator panel assembly, auxiliary indicator

panel assembly, portable indicator panel assembly, protective shield, sensing device design, and maintainability as applicable (see S7 and S9).

S11. Number of Test and Retests

S11.1 One liquid level indicating equipment of each type (that is, sensing technique, application, pressure range, display, and indication range) (see S4.1) shall be subjected to first article testing when specified (see S5.2).

S11.2 An inspection lot for conformance inspection shall consist of all liquid level indicating equipment of each type (that is, sensing technique, application, pressure range, display, and indication range) (see S4.1) produced under the same conditions and offered for inspection at the same time. Sampling and acceptance for Group A and Group B testing shall be as specified (see S5.2). When the number of rejected equipment, in any sample, exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

S12. Test Methods

S12.1 *Test Conditions*—Except where the following factors are the variables, or unless otherwise specified in the individual test procedure, the tests specified in S12.2 shall be conducted with the liquid level indicating equipment operating under the following conditions:

(a) Ambient temperature shall be 23 ± 1.0°C.
(b) Relative humidity shall be 50 ± 5 %.
(c) Supply voltage shall be 115 V ± 5 %.
(d) Supply frequency shall be 60 Hz ± 5 %.
(e) Controls shall be in the neutral or normal position.
(f) Liquid level indicating equipment shall be mounted to simulate shipboard installation and measure the liquid level along the vertical centerline of the test tank (see S12.1.1).
(g) Liquid level indicating equipment shall be configured to indicate liquid level height over a vertical distance equal to the normal operating range (height) of the sensing device.
(h) The fluid/gas or fluid/water used shall be the same as the intended application (see S4.3), except that ordinary tap water having a minimum conductivity of 400 µS may be substituted for seawater interface applications. For CF applications, the fluid used for testing shall be JP-5. For CO and WO applications, the fluid used for testing shall be lube oil 2190 in accordance with MIL-L-17331, or equal. For CF/AR and CO/AR applications, the fluid used for testing shall be water having a minimum conductivity of 400 µS with a 3- ± 0.25-in. layer of JP-5 for CF/AR and lube oil 2190 in accordance with MIL-L-17331, or equal, for CO/AR applications.
(i) The fluid temperature shall be 25 ± 10°C.

S12.1.1 *Test Tank*—The test tank shall be a carbon steel test tank coated for surface ship seawater tanks. The test tank shall be large enough to exercise the liquid level indicating equipment through the normal operating range (height) of the sensing device for tests specified herein. The tank shall have a sight glass or similar device with sufficient resolution and accuracy to determine the accuracy, repeatability, hysteresis, and dead band requirements of S8.3.

S12.2 *Tests*—The liquid level indicating equipment and all associated test equipment shall be energized for a period of time sufficient to ensure complete warm-up.

S12.2.1 *Reference Measurement*—When specified in the individual test, a reference measurement shall consist of measurements of the indicated level versus actual tank level. (When volumetric accuracy is required (see S5.2), the actual tank levels and the indicated levels shall be converted to volumetric levels using the capacity curve supplied by the contracting activity.) The measurements shall be measured at a minimum of ten equal increments, ±½ % of full scale, for both increasing (upscale) and decreasing (downscale) level. The liquid level shall be maintained at each checkpoint for a time sufficient to obtain a stable measurement, but not longer than 30 s. Reference measurement accuracy shall meet the requirements of S8.3. For fluid/water interface liquid level indicating equipment, the following conditions shall apply:

(a) The tank shall be filled over the entire normal operating range (height) of the sensing device. The tank shall be full of water, full of the measured fluid, or full of some combination of water and the measured fluid.
(b) The liquid level indicating equipment shall indicate 0 % of the sensing device normal operating range (height) when the tank is full of water.
(c) The liquid level indicating equipment shall indicate 100 % of the sensing device normal operating range (height) when the tank is full of the measured fluid.
(d) The two fluids shall not be agitated in any way to create an emulsion. The two fluids shall be allowed to separate and form a distinct interface before any measurements are taken.

S12.2.2 *Accuracy*

S12.2.2.1 *Liquid Level Indicating Equipment Operation and Accuracy*—The sensing device shall be conditioned first by raising and lowering the level between 0 and 100 % of the sensing device normal operating range (height) for three consecutive cycles. Three reference measurements (see S12.2.1) shall then be made in succession. Accuracy shall be in accordance with S8.3.

S12.2.2.2 *Control Circuit Accuracy*—The detection points for the high control circuit setpoints shall be tested at 50, 75, and 98 % of the sensing device normal operating range (height). The detection points for the low control circuit setpoints shall be tested at 2, 25, and 50 % of the sensing device normal operating range (height). The liquid level shall be raised above then lowered below each detection point three successive times. The control circuit accuracy shall be in accordance with S8.3 at each control circuit setpoint tested.

S12.2.3 *Response Time Tests*—The test tank (see S12.1.1) shall be used to subject the sensing device to changes in liquid level at a constant rate. Where it is impractical to achieve the fill/empty rate specified, this test may be performed by simulating the change in fluid level (for example, raising or lowering the sensing device by means of a pneumatic cylinder) at the same rate specified.

S12.2.3.1 *Indication Response Time Test*—This test is applicable to all liquid level indicating equipment. When an adjustable response time is provided, the liquid level indicating equipment shall be adjusted to its minimum response time setting. The actual fluid level and the level indicated by the liquid level displays shall be monitored. The test point levels shall be 20, 50, and 80 % of the liquid level indicating

equipment normal operating range (height). The fluid level shall be increased at a constant rate of 1 ± 0.01 in./s through the test points and then decreased at the same rate through the test points. The elapsed time from when the actual fluid level reaches a test point level to when the liquid level indication equipment indicates the test point level, within the specified accuracy requirements (see S8.3), shall be measured both upscale and downscale. The maximum elapsed time shall be the indication response time. Performance shall conform to the requirements of S8.4.1.

S12.2.3.2 *Control Circuit Response Time Test*—This test is applicable only to liquid level indicating equipment with control circuit(s). When two high control circuits are provided, one setpoint shall be set at 50 % and one at 80 % of the liquid level indicating equipment normal operating range (height). When two low control circuits are provided, one setpoint shall be set at 20 % and one at 50 % of the liquid level indicating equipment normal operating range (height). When one high and one low control circuit is provided, their setpoints shall be set at 80 and 20 % of the liquid level indicating equipment normal operating range (height), respectively.

S12.2.3.2.1 *Minimum Control Circuit Response Time Test*—The control circuit shall be adjusted to its minimum response time setting. The fluid level shall be increased at a constant rate of 1 ± 0.01 in./s through the test points and then decreased at the same rate through the test points. The elapsed time from when the actual fluid level reaches a test point level to when the control circuit activates or deactivates the switching device associated with that setpoint level shall be measured both upscale and downscale. The maximum elapsed time shall be the minimum control circuit response time. Performance shall conform to the requirements of S8.4.2. This test may be done concurrently with S12.2.3.1.

S12.2.3.2.2 *Maximum Control Circuit Response Time Test*—The control circuit shall be adjusted to its maximum response time setting. The fluid level shall be increased at a constant rate of 0.25 + 0.005 in./s through the test points and then decreased at the same rate through the test points. The elapsed time from when the actual fluid level reaches a test point level to when the control circuit activates or deactivates the switching device associated with that setpoint level, and the elapsed time from when the actual fluid level reaches a test point level to when the liquid level indication equipment indicates the test point level within the specified accuracy requirements (see S8.4.2) shall be measured both upstate and downscale. The maximum elapsed time between when the actual fluid level reaches a test point level to when the control circuit activates or deactivates the switching device associated with that setpoint level shall be the maximum control circuit response time. The maximum elapsed time between when the actual fluid level reaches a test point level to when the liquid level indication equipment indicates the test point level within the specified accuracy requirements (see S8.4.2) shall be the indication response time. Performance shall conform to the requirements of S8.4.2.

S12.2.4 *Insulation Resistance Test*—The insulation resistance of the liquid level indicating equipment shall be determined by applying 50 Vdc between electrical input and output circuits and between these circuits and ground. The insulation resistance measurement shall be made immediately after a 2-min period of uninterrupted test voltage application. However, if the indication of insulation resistance meets the specified limit (S8.5) and is steady or increasing, the test may be terminated before the end of the 2-min period. The accuracy test (see S12.2.2) shall be performed after completion of the insulation resistance measurements. Performance shall conform to the requirements of S8.5.

S12.2.5 *Specific Gravity Test*

S12.2.5.1 *Fluid/Gas Interface Test*—This test applies only to fluid/gas interface applications in which the fluid is FO, CO, WO, CF, or JP. Two accuracy tests (see S12.2.2) shall be performed, one using water as the test fluid and the other using an organic fluid with a specific gravity of 0.86 ± 0.02, such as lube oil. The liquid level indicating equipment shall not be altered, modified, or manually adjusted during each accuracy test or between the two accuracy tests. Performance shall conform to the requirements of S8.6.

S12.2.5.2 *Fluid/Water Interface Test*—This test applies only to fluid/water interface applications in which the fluid is FO, CO, WO, CF, or JP. Two accuracy tests (see S12.2.2) shall be performed, the first using water and an organic fluid with a specific gravity of 0.86 ± 0.02, such as lube oil as the test fluids, and the second using water and another fluid with a specific gravity of 0.78 ± 0.02, such as kerosene, as the test fluids. The liquid level indicating equipment shall not be altered, modified, or manually adjusted during each accuracy test or between the two accuracy tests. Performance shall conform to the requirements of S8.6.

S12.2.6 *Fluid Conductivity Test*—This test applies only to SW, FW, WW, CO, CF, and WO applications. Three accuracy tests (see S12.2.2) shall be performed using water with a different electrical conductivity for each test. The three test conductivities of water shall be 3 ± 2, 500 ± 50, and 10 000 ± 50 µS/cm. The conductivity of the water shall be controlled by varying the concentration of sodium chloride in solution with the water. The liquid level indicating equipment shall not be altered, modified, or manually adjusted during each accuracy test or between the accuracy tests. Performance shall conform to the requirements of S8.7.

S12.2.7 *Tank Wall Proximity Test*—The sensing device shall be located at a corner of the test tank that is formed by two continuous steel walls and shall be equidistant from each of the two adjoining walls. The distance to each wall shall either provide 1 in. of clearance between the sensing device and the wall or shall be the minimum distance specified by the manufacturer up to a maximum of 4 in. An accuracy test (see S12.2.2) shall be performed. Performance shall conform to the requirements of S8.8.

S12.2.8 *Inclination*—The accuracy test (see S12.2.2) shall be performed except that the liquid level indicating equipment and the test tank shall be inclined 45°, unless otherwise specified (see S5.2), to each side of vertical along both the fore-and-aft and athwartship axes of the tank, for a total of four positions. Reference measurements (see S12.2.1) shall be taken in each of the four inclined positions. The actual liquid level

shall be measured at the inclined vertical tank centerline. Performance shall conform to the requirements of S8.9.

S12.2.9 *Spike Voltage Test*—The liquid level indicating equipment shall be subjected to an input supply line voltage spike of 2500-V positive peak amplitude; the voltage waveshape shall be in accordance with MIL-STD-1399, Section 300, Fig. 2, Voltage Spike Impulse Wave Shape. This spike shall be impressed at normal supply line voltage and frequency while the liquid level indicating equipment is operating. The accuracy test (see S12.2.2) shall be performed at the conclusion of the test. Performance shall conform to the requirements of S8.10.

S12.2.10 *Accelerated Life Test*—Liquid level indicating equipment shall be subjected to the accelerated life test as specified herein. Throughout the test, the temperature of the fluid in the test tank shall be within plus or minus 5°C of the required test chamber temperature. The liquid level in the tank shall be continuously cycled from empty to full throughout the test. If the test tank is sealed from the ambient environment, the humidity inside the test tank need not meet the test chamber humidity requirements. Performance shall conform to the requirements of S8.11.

S12.2.10.1 *Initial Test Conditions*—The test shall begin with the following initial conditions:

(a) Equipment set up in a temperature-controlled chamber at 25 ± 5°C and relative humidity of 90 to 100 %.

(b) Equipment energized.

1—Nominal line voltage of 115 V ± 5 % and nominal frequency of 60 Hz + 5 %.

2—Fully operational for 2 h.

(c) When equipment internal temperature has stabilized, performance parameters shall be measured as reference test data for comparison with subsequent tests.

S12.2.10.2 *Temperature Conditions*—After initial test conditions have been satisfied, temperature testing shall be performed as follows:

(a) Reduce chamber temperature, at a uniform rate in not less than 4 h, to the lowest operating temperature of the range specified and maintain relative humidity of 90 to 100 %.

(b) Maintain chamber temperature at the lowest operating temperature of the range for 4 h.

(c) Near the end of the fourth hour, measure performance parameters specified in S8.12.

(d) Increase chamber temperature, at a uniform rate in not less than 6 h, to the highest operating temperature of the range specified and maintain humidity at 90 to 100 %.

(e) Maintain chamber temperature at the highest operating temperature of the range specified for 4 h.

(f) Near the end of the fourth hour, measure performance parameters specified in S8.12.

(g) Reduce chamber temperature, at a uniform rate in not less than 6 h, to the lowest operating temperature of the range specified and maintain humidity at 90 to 100 %.

(h) Maintain chamber temperature at the lowest operating temperature of the range specified for 2 h.

S12.2.10.3 *Voltage and Frequency Cycling Conditions*—After completion of the 2-h low-temperature conditioning period specified in S 12.2.10.2(h), perform the following:

(a) Decrease the input voltage to the lowest limit of the equipment voltage tolerance band.

(b) Maintain chamber temperature at the lowest operating temperature and input voltage at the lowest limit for 1 h while equipment continues to operate, then measure performance parameters specified in S8.11.

(c) Return input voltage to nominal value. Decrease input frequency to the lower limit of the equipment frequency tolerance band.

(d) Maintain chamber temperature at the lowest operating temperature and input frequency at the lowest limit for 1 h while equipment continues to operate, then measure performance parameters specified in S8.11.

(e) Return input frequency to nominal value.

(f) Increase temperature to 25 ± 5°C and maintain relative humidity at 90 to 100 %. Maintain this condition for 2 h.

(g) With equipment operating at 25 ± 5°C and relative humidity at 90 to 100 %, decrease input voltage and frequency to the lower limits of the equipment voltage and frequency tolerance bands. Maintain this condition for 1 h and then measure performance parameters specified in S8.11.

(h) Repeat S12.2.10.3(g) with input voltage at the upper limit of the equipment voltage tolerance band and input frequency at the lower limit of the equipment frequency tolerance band.

(i) Repeat S12.2.10.3(g) with input voltage and frequency at the upper limits of the equipment voltage and frequency tolerance bands.

(j) Repeat S12.2.10.3(g) with input voltage at the lower limit of the equipment voltage tolerance band and input frequency at the upper limit of the equipment frequency tolerance band.

(k) Repeat uniform temperature rise test of S 12.2.10.2(d).

(l) Measure performance parameters specified in S8.12 at the end of the uniform temperature rise test of S 12.2.10.3(k).

(m) With equipment operating at the highest operating temperature of the range specified and relative humidity at 90 to 100 %, increase input voltage to the upper limit of the equipment voltage tolerance band, maintaining input frequency at the upper limit of the equipment frequency tolerance band.

(n) Operate for 4 h at this condition and measure performance parameters specified in S8.11.

(o) Maintain input frequency at the upper limit of the equipment frequency tolerance band but decrease input voltage to the lower limit of the equipment voltage tolerance band.

(p) Operate for 1 h at this condition and measure performance parameters specified in S8.11.

(q) Maintain high temperature and humidity conditions but return input voltage and frequency to nominal values.

(r) Operate for 1 h at this condition and measure performance parameters specified in S8.11.

(s) Reduce temperature to 25 ± 5°C and maintain relative humidity at 90 to 100 %. Maintain this condition for 2 h.

(t) Repeat temperature, voltage, and frequency cycling tests of S12.2.10.3(g) through (s) with relative humidity at 90 to 100 % for not less than eight cycles.

(u) Repeat uniform temperature rise test of S12.2.10.2(d).

(v) Repeat temperature, voltage, and frequency cycling tests of S12.2.10.3(m) through (r) with relative humidity at 10 to 20 % for not less than ten cycles.

(w) Reduce chamber temperature, at a uniform rate in not less than 6 h, reduce relative humidity to 45 to 55 % and return temperature, voltage, and frequency to nominal values specified in S12.2.10.1.
(x) Operate for 2 h at this condition and perform accuracy (see S12.2.2) and response time (see S12.2.3) tests.

S12.2.11 *Enclosure Test*—Each liquid level indicating equipment enclosure to be installed partially or totally outside the tank shall be subjected to the tests in NEMA Standard 250 for Type 4X enclosures. The portable indicator assembly shall be subjected to the tests in NEMA Standard 250 for Type 6 enclosures. Performance shall conform to the requirements of S8.12.

S12.2.12 *Pressure Test*—The components of the liquid level indicating equipment, including flexible interconnections, subject to immersion in the measured fluid, shall be installed in a pressure vessel to simulate actual tank installation so that all parts of the components, especially connections and fittings, are submerged and remain submerged except when test conditions state otherwise. Before testing, the pressure vessel with the liquid level indicating equipment installed shall be filled and allowed to soak for 1 h at atmospheric pressure. Except for the AP pressure range (see S4.4), the rate of pressure change shall not be less than 10 lb/in.^{2}·s. For the AP pressure range, the rate of pressure change shall not be less than 5 lb/in.^{2}·s.

S12.2.12.1 *Pressure Test Procedure*—The pressure test shall consist of three successive fill and empty cycles. The pressure vessel shall be filled in ten equal increments through the sensing device normal operating range (height) at atmospheric pressure and level readings taken at each increment. The specified pressure (see below) shall then be applied and held for 1 h. While maintaining the specified pressure with compressed gas, the pressure vessel shall be emptied in ten equal increments and level readings shall be taken at each increment. The pressure shall then be reduced to atmospheric for 10 min and the cycle repeated twice. During the third pressure cycle, an insulation resistance measurement (see S12.2.4) shall be made on the sensing device at both the specified pressure and at atmospheric pressure. The specified pressure for the test shall be as follows:
(a) AP pressure range sensing devices shall be subjected to 30 psig.
(b) VP and LP pressure range sensing devices shall be subjected to 150 psig.
(c) HP pressure range sensing devices shall be subjected to 150 % of the maximum pressure specified (see S5.2).

S12.2.12.2 *Posttest Inspection*—Upon completion, the sensing device shall then be removed from the pressure vessel and disassembled to the maximum extent possible without affecting sensing device performance or integrity. The sensing device shall be examined for any physical or electrical damage and leakage or signs of leakage. The sensing device shall then be reassembled and a reference measurement (see S12.2.1) taken. Performance shall conform to the requirements of S8.13.

S12.2.13 *Vibration Test*—Liquid level indicating equipment shall be tested in accordance with Type I (environmental) vibration of MIL-STD-167-1. Components of the liquid level indicating equipment, including sensing devices, shall be mounted to simulate shipboard installations in an empty tank and shall not be restricted from normal operation and movement. The equipment under test shall be energized in the normal manner. At the conclusion of the test and before any adjustments, accuracy shall be measured (see S12.2.2). Liquid level indicating equipment shall be physically examined for evidence of mechanical or electrical damage or loosening of parts. Performance shall conform to the requirements of S8.14.

S12.2.14 *Shock Test*—Liquid level indicating equipment shall be tested in accordance with Grade A, Class 1, Type A equipment as specified in MIL-S-901. The liquid level indicating equipment shall be energized in the normal manner. Components of the liquid level indicating equipment, including sensing devices, shall be mounted to simulate shipboard installation in an empty tank and shall not be restricted from normal operation and movement. If individual components of the liquid level indicating equipment must be shock tested separately because of size or weight, the complete liquid level indicating equipment shall be connected together (electrically and mechanically) as designed, energized, and the output and control circuit signals monitored during the test. At the conclusion of the test and before any adjustments, the accuracy shall be measured as specified in S12.2.2. The liquid level indicating equipment shall be physically examined for evidence of mechanical or electrical damage or loosening of parts. Performance shall conform to the requirements of S8.15.

S12.2.15 *DC Magnetic Field*—The liquid level indicating equipment shall be tested in accordance with MIL-STD-1399, Section 070, Part l. Unless otherwise specified (see S5.2), the magnetic field strength shall be 400 A/m. Performance shall conform to the requirements of S8.16.

S12.2.16 *Electromagnetic Interference Tests*—EMI tests shall be in accordance with the test methods specified in MIL-STD-461, with the modifications as specified in S8.17. Upon completion of the EMI tests, an accuracy test (see S12.2.2) shall be performed. Performance shall conform with the requirements of S8.17.

S12.2.17 *Flexible Interconnection Immersion Test*—When intended for use in tanks containing CF, CO, WO, FO, or JP type fuels, flexible interconnections shall be submerged in JP5 for a continuous period of 45 days. The test fluid temperature shall be maintained at 25 ± 10°C. Removable flexible interconnections may be tested with a simulated shipboard installation using test fixtures to replace sensing devices. After completion of immersion testing, the flexible interconnection shall undergo a physical examination and insulation resistance test (see S 12.2.4). Performance shall conform to the requirements of S8.18.

S12.2.18 *Supply Line Voltage and Frequency Variation*—Liquid level indicating equipment shall be operated at normal, maximum, and minimum steady state voltages and frequencies (see S8.11.1). The liquid level indicating equipment shall remain at each configuration for 15 min. A reference measurement (see S12.2.1) shall be performed before and after each transition. Performance shall conform to the requirements of S8.11. l.

S13. Certification

S13.1 The purchase order or contract should specify whether the buyer shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. The purchase order or contract should specify when a report of the test results shall be furnished. Otherwise, the purchase order or contract should specify that all test data remain on file for three years at the manufacturer's facility for review by buyer upon request.

S14. Product Marking

S14.1 *Marking*—Unless otherwise specified (see S5.2), all major liquid level indicating equipment components shall be marked or provided with label plates. Markings on plastic or metallic materials shall be made by stamping, engraving, stenciling, or rubber-stamping with smudgeproof ink covered with a coat of clear lacquer or silk screening. Label plates shall be made with engraved or stamped markings. At a minimum, labels and markings shall contain:

(a) "LIQUID LEVEL INDICATOR,"
(b) Component name,
(c) Manufacturer's name,
(d) National Stock Number (NSN), if available,
(e) Date of manufacture, and
(f) Designation (see S4.1).

A label plate marked with manufacturer's part number and serial number shall be permanently affixed on the front of each indicator panel assembly.

S15. Packaging and Package Marking

S15.1 Packaging and package marking shall be in accordance with Section 15.

S16. Quality Assurance

S16.1 *Quality System*—A quality assurance system in accordance with ISO 9001 shall be maintained to control the quality of the product being supplied effectively, unless otherwise specified in the acquisition requirements (see S5.2).

S16.2 *Warranty*—Any special warranty requirements shall be specified in the acquisition requirements (see S5.2).