



# Standard Specification for Liquid Level Indicating Equipment, Electrical<sup>1</sup>

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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 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<sup>2</sup>

2.2 *ISO Standards:*

9001 Quality System Model for Quality Assurance in Design/Development, Production, Installation, and Servicing<sup>3</sup>

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

Current edition approved July 10, 2000. Published September 2000.

<sup>2</sup> Available from the *Annual Book of ASTM Standards*, Vol 15.09.

<sup>3</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

## 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 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:

- Title, number, and date of this specification;
- Manufacturer's part number;
- Sensing technique;
- Application;
- Pressure range;
- Display requirements (see 4.5) and indication range;
- Indicator panel assembly mounting method;
- Indicator panel assembly requirements;
- System operating characteristics;
- Materials;
- Environmental requirements;
- Quantity of liquid level indicating equipment required;
- Size and weight restrictions (see 7.5);
- Critical service life requirements (see 8.1);
- Performance requirements (see 8.2);
- Special surface finish requirements (see 9.1);
- When certification is required (see Section 13);
- 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<sup>4</sup>

#### S2.2 *ISO Standards:*

9001 Quality System—Model for Quality Assurance in Design/Development, Production, Installation, and Servicing<sup>5</sup>

#### S2.3 *Military Standards:*

MIL-C-17 Cables, Radio Frequency, Flexible, Coaxial<sup>6</sup>

MIL-C-915 Cable and Cord, Electrical, for Shipboard Use, General Specifications for<sup>6</sup>

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<sup>6</sup>

MIL-S-901 Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for<sup>6</sup>

MIL-S-16032 Switches and Detectors, Shipboard Alarm Systems<sup>6</sup>

MIL-STD-167-1 Mechanical Vibrations of Shipboard Equipment (Type I—Environmental and Type II—Internally Excited)<sup>6</sup>

MIL-STD-461 Electromagnetic Interference Characteristics of Subsystems and Equipment, Requirements for the Control of<sup>6</sup>

MIL-STD-1399 Section 070, Interface Standard for Shipboard Systems, D.C. Magnetic Field Environment<sup>6</sup>

MIL-STD-1399 Section 300, Interface Standard for Shipboard Systems, Electric Power, Alternating Current<sup>6</sup>

#### S2.4 *NEMA Standards:*

250 Enclosures for Electrical Equipment (1000 V Maximum)<sup>7</sup>

### 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

<sup>4</sup> Available from American Bureau of Shipping, 2 World Trade Center, 106th Floor, New York, NY 10048.

<sup>5</sup> Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

<sup>6</sup> Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

<sup>7</sup> Available from NEMA, 1300 N. 17th St., Suite 1847, Rosslyn, VA 22209.

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

**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  $40 \pm 10\%$  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,