

INCH-POUND
MIL-F-24701(SH)
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MILITARY SPECIFICATION

FLOWMETER, LIQUID, ULTRASONIC, NON-INTRUSIVE

This specification is approved for use within the Naval Sea Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

1. SCOPE

1.1 Scope. This specification covers the requirements for non-intrusive, ultrasonic, liquid flow measuring equipment including the digital readout for use on Naval surface ships and submarines.

1.2 Type and characteristics.

1.2.1 Type. The flowmeters covered by this specification shall be of the ultrasonic type employing the non-intrusive, transit time transduction principle.

1.2.2 Characteristics. The flowmeters covered by this specification shall have the characteristics specified in 1.2.2.1 through 1.2.2.7.

1.2.2.1 Application. The liquid measured shall be sea water, fresh water, fuel oil, lube oil, or other liquids as specified in the contract or order (see 6.2.1).

1.2.2.2 Range.

1.2.2.2.1 Flow rate range. The range of liquid flow rate measured shall be as specified in 3.3.9.4 (see 6.2.1).

1.2.2.2.2 Flow totalization. The flow totalization capability of the flowmeter equipment shall range from zero to all nine's for the number of decimal digits specified in the contract or order (see 6.2.1 and 3.3.12). If unspecified, the number of decimal digits shall be five.

Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to: Commander, Naval Sea Systems Command, SEA 5523, Department of the Navy, Washington, DC 20362-5101 by using the self-addressed Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1.2.2.3 Flow rate meter option. When specified in the contract or order (see 6.2.1), a flow rate meter shall be located in the equipment locations as specified (see 3.3.12).

1.2.2.4 Remote control/readout units. Unless otherwise specified (see 3.3.12 and 6.2.1), two remote control/readout units per flowmeter system shall be provided.

1.2.2.5 Up-down flow totalizer option. When specified in the contract or order (see 6.2.1), the flowmeter equipment shall decrement the totalizer readouts when the measured liquid flow reverses from that direction which causes the flow totalizers to increase in readout value.

1.2.2.6 Low flow rate exclusion option. When specified in the contract or order (see 6.2.1), flow rates below a specified or adjustable value shall be ignored by the flow totalizers. This option is useful, for example, to prevent "sloshing" back and forth of liquid in the monitored pipe from giving false liquid transfer indication, especially when uni-directional flow totalizers are employed.

1.2.2.7 Multiplex data bus option. When specified in the contract or order (see 6.2.1), the flowmeter equipment shall interface with a time division command/response multiplex data bus system in accordance with MIL-STD-1553.

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications, standards, and handbook. The following specifications, standards, and handbook form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of these documents shall be those listed in the issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

FEDERAL

PPP-F-320 - Fiberboard, Corrugated and Solid, Sheet Stock (Container Grade), and Cut Shapes.

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MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
 MIL-P-15024 - Plates, Tags and Bands for Identification of Equipment.
 MIL-E-16400 - Electronic, Interior Communication and Navigation Equipment, Naval Ship and Shore, General Specification for.
 MIL-E-17555 - Electronic and Electrical Equipment, Accessories, and Provisioned Items (Repair Parts): Packaging of.
 MIL-L-19140 - Lumber and Plywood, Fire-Retardant Treated.
 MIL-R-28803 - Readouts, Segmented, General Specification for.

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STANDARDS

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- MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
- MIL-STD-108 - Definitions of and Basic Requirements for Enclosures for Electric and Electronic Equipment.
- MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
- MIL-STD-202 - Test Methods for Electronic and Electrical Component Parts.
- MIL-STD-454 - Standard General Requirements for Electronic Equipment.
- MIL-STD-461 - Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference.
- MIL-STD-462 - Electromagnetic Interference Characteristics, Measurement of.
- MIL-STD-470 - Maintainability Program for Systems and Equipment.
- MIL-STD-471 - Maintainability Verification/Demonstration/Evaluation.
- MIL-STD-781 - Reliability Testing for Engineering Development, Qualification and Production.
- MIL-STD-785 - Reliability Program for Systems and Equipment Development and Production.
- MIL-STD-810 - Environmental Test Methods and Engineering Guidelines.
- MIL-STD-1388 - Logistic Support Analysis.
- DOD-STD-1399, Section 300 - Interface Standard for Shipboard Systems Electric Power, Alternating Current. (Metric)
- MIL-STL-1553 - Aircraft Internal Time Division Command/Response Multiplex Data Bus.
- MIL-STD-45662 - Calibration Systems Requirements.

HANDBOOK

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- MIL-HDBK-217 - Reliability Prediction of Electronic Equipment.

(Copies of specifications, standards, and handbooks required by contractors in connection with specific acquisition functions should be obtained from the contracting activity or as directed by the contracting activity.)

2.2 Order of precedence. In the event of a conflict between the text of this specification and the references cited herein (except for associated detail specifications, specification sheets or MS standards), the text of this specification shall take precedence. Nothing in this specification, however, shall supersede applicable laws and regulations unless a specific exemption has been obtained.

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3. REQUIREMENTS

3.1 First article. When specified in the contract or purchase order, a sample shall be subjected to first article inspection (see 4.4 and 6.3).

3.2 Materials. Material shall be in accordance with 3.2.1, 3.2.2, and as specified herein.

3.2.1 Parts, materials and processes. The selection, usage, and methods of implementation of parts, materials and processes shall be in accordance with MIL-E-16400. Cadmium plating shall not be used.

3.2.2 Nonmetallic material. When used for seals, protective finishes, and so forth, nonmetals shall be moisture and flame resistant, shall not support fungus growth, and shall not be adversely affected by the ambient environments specified herein.

3.3 Construction. Flowmeter construction shall be in accordance with 3.3.1 through 3.3.16.

3.3.1 General. The flowmeter equipment shall be in accordance with the type, transduction principle, application, range, and multiplex data bus option specified in 1.2. Unless otherwise specified (see 6.2.1), the flowmeter equipment shall consist of three subunits: the transducer assembly, the signal conditioner, and the remote display/control units. Each transducer assembly consists of two or more transmit/receive transducers attached to the outside of the pipe by an appropriate mounting assembly. Transmit and receive connections to the flow computer are made through coaxial cables. The signal conditioner shall interface with the transducer assembly and two remote control/readout assemblies. These remote control/readout assemblies shall provide the functions specified in 3.3.12.

3.3.2 Accessibility. Parts and subassemblies which may require servicing, repair, or replacement during the life of the flowmeter equipment shall be readily accessible for repair or replacement.

3.3.3 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.

3.3.4 Painting and color. When specified in the contract or purchase order, the flowmeter equipment and associated subunits shall be painted in accordance with MIL-E-16400, except for any sensing surfaces of the transducer or other parts wherein painting would impair meeting the requirements of this specification. The color shall be in accordance with MIL-E-16400. (Stainless steel shall not be painted when present.)

3.3.5 Multiple flowmeter in one system. When specified in the contract or order (see 6.2.1), multiple flowmeters shall be installed so that flow in more than one pipe can be measured. If multiple flowmeters are specified, all of the provisions of this specification shall apply to each channel.

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3.3.6 Power input. The flowmeter equipment shall meet all of the requirements of this specification when supplied with type I, 115 volts, alternating current (ac), 60 hertz (Hz), ungrounded electrical power in accordance with DOD-STD-1399, section 300.

3.3.7 Electro-static discharge warning. Where devices that are sensitive to electro-static discharge such as complementary metal oxide semiconductor (CMOS) devices are used, a note on the printed board or subassembly shall indicate to handle with special care due to the possibility of electro-static discharge damage.

3.3.8 Illumination. When specified in the contract or order (see 6.2.1), illumination shall be provided in accordance with MIL-E-16400.

3.3.9 Transducer.

3.3.9.1 Pipe size and type. When the transducer is matched to the size and type of pipe as specified in the contract or order (see 6.2.1), the flowmeter equipment shall meet all of the requirements of this specification.

3.3.9.2 Liquids. The liquids whose flow is to be measured, and their characteristics to the maximum extent known, shall be as specified in the contract or order (see 6.2.1).

3.3.9.3 Liquid temperature. The requirements of this specification shall be met with liquid temperature variations over the minimum range of 28 to 160 degrees Fahrenheit ($^{\circ}$ F).

3.3.9.4 Flow rate. The flowmeter equipment shall meet all of the requirements of this specification with the range of flow rates as specified in the contract or order (see 6.2.1). If not specified in the contract or order, the default flow rate range of at least plus or minus 22 feet per second shall be provided for systems utilizing bi-directional flow transfers and readouts; or 0 to at least 22 feet per second for systems utilizing only unidirectional liquid flow readouts or liquid transfer.

3.3.9.5 Sensor orientation. The sensor shall meet the requirements of this specification when installed on pipe which has an angular orientation from horizontal to vertical. When installed on horizontal pipe, the transducers shall be mounted in a horizontal plane to avoid interference from possible sediment lying at the bottom of the pipe and air bubbles at the top of the pipe.

3.3.9.6 Straight pipe. Flow transducers shall minimize lengths of straight piping required at the transducer inlet and outlet in order that the equipment will operate within the accuracy limits specified in 3.4.1. Required lengths of straight, unobstructed piping shall not exceed three diameters (with reference to the inside nominal pipe diameter) at the inlet of the flow transducer and three diameters at the outlet of the flow transducer.

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3.3.9.7 Continuous excitation. The flow transducers shall withstand continuous, worst-case (maximum) excitation under conditions of the pipe completely void of liquid as well as full of liquid and any condition between empty and full, and with the ambient and liquid temperatures at the highest points of the range specified herein.

3.3.10 Signal conditioner.

3.3.10.1 Connection to other assemblies of the flowmeter equipment.

3.3.10.1.1 Connection to transducer assembly. A sufficient connection system (usually a coaxial connection to each of the two transducers of one transducer assembly) shall be provided so that the flowmeter equipment shall meet all of the requirements of this specification. Unless otherwise specified in the contract or order (see 6.2.1), the length of cable to the transducer assembly shall be 100 ± 1.5 feet. The maximum cable length capability shall be 500 feet.

3.3.10.1.2 Connection to remote control/readout assemblies. A connection system shall be provided to remote control/readout assemblies so that the flowmeter equipment shall meet all of the requirements of this specification. Unless otherwise specified in the contract or order (see 6.2.1), the length of cable to the remote control/readout assembly shall be 100 ± 1.5 feet. The maximum cable length capability shall be 500 feet.

3.3.10.2 Signal from and to remote control/readout assemblies. The signal for each digit shall be either multiplexed in order to reduce the number of wires in the interconnecting cable, or an equal or better system in terms of reliability, size and weight. Unless otherwise specified in the contract or order (see 6.2.1), a five decimal digit readout up to 99,999 (X10) pounds total flow shall be provided for. The signal conditioner shall accept any control signals that associated remote control/readout units supply, and perform the intended functions. Examples of these functions are reset, which zeroizes the flow totalizer, and test, which causes a self-test to be performed.

3.3.11 Controls and indicators. The following controls and indicators shall be provided.

3.3.11.1 Low flow rate reject control. When specified in the contract or order (see 6.2.1), means shall be provided which shall ensure that flow rates below the specified amount plus or minus 5 percent shall be excluded from flow totalization. Unless otherwise specified (see 6.2.1), a control shall be provided that will vary the reject cutoff point from zero to the amount specified plus a minimum of 30 percent. If a flow velocity meter is included in the system, it shall register down to zero flow and not be affected by the totalization low flow rate reject system.

3.3.11.2 Calibration and maintenance controls. Controls shall be provided, if required, to perform calibration and maintenance so that the equipment will meet the requirements of this specification over the life of the equipment. A control may be required for scale factor and shall be provided to meet the above calibration requirement when the units are mass produced.

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3.3.11.2.1 Maintenance accessibility. A "test" connector or equivalent means shall be provided for easy access to internal signals for testing, calibration, and troubleshooting purposes. If technically feasible, an extender card, stowed in a spare slot, shall be provided to troubleshoot any plug-in cards. The test connector and extender card requirements are waived for miniaturized equipment where replacement of the whole assembly is required.

3.3.11.3 Fine tuning control and indicator. A fine tuning control and indicator shall be provided when required to meet the requirements of this specification, for example, to adjust the ultrasonic frequency generated by the signal conditioner to match the requirement of the transducer.

3.3.11.4 Fault indicator. Unless otherwise specified in the contract or order (see 6.2.1), a signal to energize an indicator shall be provided when required to meet the requirements of this specification, to alert personnel that the received signal has not been detected within a preprogrammed time interval. This indicator shall be energized during normal operation due to temporary liquid conditions (such as bubbles or non-sonically conductive matter), and deenergized automatically whenever the proper timing resumes. When specified in the contract or order (see 6.2.1), the fault indication signal or a signal containing more information (for example, fault or empty pipe) shall be transmitted to the specified remote control/readout units.

3.3.11.5 Reynold's number compensation. Unless otherwise specified (see 6.2.1), a means shall be provided to connect or enter Reynold's number compensation into the signal conditioner. All of the requirements of this specification with the compensation attached or entered shall be met.

3.3.11.6 Reverse flow indicator. When specified in the contract or order (see 6.2.1), an LED reverse flow indicator shall be provided in the locations specified.

3.3.11.7 Empty pipe indicator. Unless otherwise specified in the contract or order (see 6.2.1), an empty pipe indicator shall be provided.

3.3.12 Remote control readout. Unless otherwise specified in the contract or order (see 6.2.1), two remote control/readout units shall be provided with each system. Unless otherwise specified in the contract or order (see 6.2.1), each remote control/readout unit shall provide a five-decimal digit LED readout for total pounds of liquid transferred, the least significant digit representing 10 pounds, unless otherwise specified (see 6.2.1). When specified in the contract or order (see 6.2.1), a digital readout shall be provided for flow rate with sufficient number of decimal digits to provide 0.5 percent or better resolution of the maximum flow rate specified in 3.3.9.4. LED readouts when used shall be in accordance with MIL-R-26803. Two types of remote control/readout units shall be available: a master remote control/readout unit and a simpler slave readout unit. Both types of remote control/readout units shall contain, in addition to the above specified readout, the following:

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- (a) Master reset. This control, located on the master unit, shall zeroize all total flow readouts and associated registers when activated, but some registers may retain previous flow information for other purposes. If a flow velocity readout is provided, this shall be unaffected. To prevent inadvertent actuation, the reset control actuation shall require two distinct operations within a 6 ± 2 -second time period, such as pull out and depress. The simpler slave unit shall only zeroize its own (local) flow totalizer, and the slave unit reset control shall be labeled "Local Reset".
- (b) Test. This control, when actuated, shall cause the flowmeter system to test itself to the greatest extent possible in the minimum time. To prevent inadvertent actuation, the actuation required shall be the same as the master reset control. Both types of remote control/readout units shall initiate this test function.

3.3.12.1 Optional controls and indication. If included in the flowmeter's construction or when specified in the contract or order (see 6.2.1), indicators shall be supplied in the remote control/readout units, including, but not limited to:

- (a) Low flow rate reject indicator.
- (b) Fault indicator.
- (c) Reverse flow indicator.
- (d) Empty pipe indicator.

3.3.13 Physical and mechanical requirements.

3.3.13.1 Mounting. When specified in the contract or order (see 6.2.1), the mounting of the flowmeter equipment shall be in accordance with MIL-E-16400.

3.3.13.2 Degree of enclosure. The flowmeter equipment shall be splashproof in accordance with MIL-STD-108. Accumulation of water within the equipment enclosure or failure of the equipment to operate satisfactorily shall be cause for rejection (see 4.8.7).

3.3.13.3 Size and weight. The size and weight of each major subunit of the flowmeter equipment shall be kept to a minimum consistent with good construction. The maximum size and weights and special shape of the major assemblies shall be as follows:

3.3.13.3.1 Size. The maximum overall dimensions of the major assemblies shall be:

- (a) Signal conditioner. The signal conditioner dimensions shall be 15 inches high by 11.4 inches wide by 10 inches deep.
- (b) Flow transducer. The maximum overall dimensions of the transducer shall be less than that size that will fit within a rectangular box with the following dimensions, where "D" is the outside diameter of the pipe, in inches, onto which the transducer is mounted (assume the transducer pair is mounted in the horizontal plane):

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width - $(1.2D + 6)$ inches.

height - 1.8D inches or 3.5 inches whichever is greater.

length - $(10 + D)$ inches.

The above dimensions include the pipe and connector jacks, but not the connecting cables and their plugs.

(c) Remote control/readout assembly. The maximum overall dimensions of remote control/readout assembly shall be:

- (1) Face of unit - 4-1/2 by 4-1/2 inches.
- (2) Depth of unit - 6-3/4 inches.

3.3.13.3.2 Weight. The maximum weight of the major subunits shall be as follows:

- (a) Transducer assembly - 1 plus 0.2D pounds (where D is the nominal pipe diameter in inches).
- (b) Signal conditioner unit - 23 pounds.
- (c) Remote readout unit - 2 pounds.

3.3.13.4 Miniaturization option. When specified in the contract or order (see 6.2.1), the electronics of the flowmeter equipment shall be miniaturized by the use of integrated or hybrid circuits or other technology and may be physically combined with the transducer or the remote control/readout unit in order to save volume and weight, especially for submarine applications.

3.3.14 Nameplates. A nameplate in accordance with MIL-P-15024 shall be affixed to each assembly of the flowmeter equipment/system except that, in accordance with MIL-E-16400, adhesive backed identification plates (type G of MIL-P-15024) shall not be used. As a minimum, the nameplates affixed to the signal conditioner shall contain the following information:

- (a) The name "FLOWMETER, ULTRASONIC".
- (b) The name of the assembly: "SIGNAL CONDITIONER".
- (c) Model and serial numbers in accordance with the identification and marking provisions of MIL-E-16400.
- (d) Technical characteristics as specified in 1.2.
- (e) Power requirements (see 3.3.6).

3.3.14.1 Transducer nameplate. The nameplate of the transducer assembly shall contain, as a minimum, the following information:

- (a) Name: "FLOWMETER TRANSDUCER, ULTRASONIC".
- (b) If calibrated with the signal conditioner and thus non-interchangeable, the model and serial number of the signal conditioners it must be connected to in use.
- (c) Technical characteristics that are applicable, such as application (sea water, oil fresh water, and so forth), range if restricted to that range, pipe diameter and type as applicable.
- (d) Any model or serial number as applicable.

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3.3.14.2 Remote control/readout nameplate. The nameplate or equivalent of the remote control/readout assembly shall contain, as a minimum, the following information:

- (a) Name: "FLOWMETER REMOTE CONTROL/READOUT" (master or slave).
- (b) The signal conditioners that it can be used with.
- (c) Units of the readout and full scale capacity of the readout, if applicable.
- (d) Other technical data as applicable.

3.3.15 Human engineering. The flowmeter equipment shall provide for safe and effective operation, maintenance and calibration capability. Direction in these areas may be obtained from requirement 62 of MIL-STD-454.

3.3.16 Safety. Personnel safety requirements shall be in accordance with requirement 1 of MIL-STD-454.

3.4 Performance.

3.4.1 Flow system accuracy. The indicated totalization readouts shall not deviate by more than 2 percent or 20 pounds, whichever is greater, from the actual quantity of liquid transferred (see 4.8.1). If a flow rate meter is provided, it shall indicate within plus or minus 2 percent of true flow rate.

3.4.2 Repeatability. The flowmeter shall have a repeatability of plus or minus 0.2 percent plus 1 least significant digit of the actual flow total.

3.4.3 Warm-up time. The flowmeter shall attain a value within plus or minus 2 percent of the steady-state flow indication in 10 minutes or less, and shall remain in this band.

3.4.4 Inclination. The flowmeter shall meet the accuracy requirement of this specification (see 3.4.1) when tested in accordance with the submarine requirement of MIL-E-16400 (see 4.8.5).

3.4.4.1 Sensor orientation. The flowmeter shall meet the accuracy requirement of this specification (see 3.4.1) with the transducer installed on pipe which has any angular orientation from horizontal to vertical.

3.4.5 Supply voltage and frequency (steady state). Maximum differences between readouts at the deviant and normal (115 volts, 60 Hz) supply voltage and frequency conditions, with the same flow transferred, shall not exceed 1 percent (see 4.8.11).

3.4.6 Supply voltage and frequency transients.

3.4.6.1 Voltage. The total flow readout obtained by the voltage transient tests of 4.8.12.1 shall not differ from a reference test by more than 1 percent.

3.4.6.2 Frequency. The total flow readout shall not differ from a reference test by more than 1 percent (see 4.8.12.2).

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3.4.6.3 Spike voltage. The flowmeter shall meet the accuracy requirement of 3.4.1 (see 4.8.12.3).

3.4.7 Ambient temperature. The equipment shall meet the accuracy requirement of 3.4.1 at all operating temperatures (see 4.8.10).

3.4.7.1 Post temperature test. The flowmeter shall meet the accuracy requirement of 3.4.1 (see 4.8.10).

3.4.8 Humidity. The flowmeter shall meet the accuracy requirement of 3.4.1 for all operational checks (see 4.8.13).

3.4.9 Salt fog. The flowmeter shall withstand the effects of salt fog (see 4.8.8). After completion of the test and cleaning, no appreciable corrosion or other damage shall be evident. The performance of the flowmeter shall be unaffected. The flowmeter shall meet the accuracy requirement of 3.4.1 after the test.

3.4.10 Insulation resistance. The insulation resistance between electrical circuits and ground shall be not less than 10 megohms (see 4.8.3).

3.4.11 Vibration. Operating and maintenance controls shall not change settings (see 4.8.14). There shall be no evidence of mechanical or electrical damage or loosening of parts. After vibration, the flowmeter shall meet the accuracy requirements of 3.4.1 without adjustment of controls.

3.4.12 Shock. The complete flowmeter system shall conform to grade A, class I, type A requirements of MIL-S-901. After the shock test of 4.8.15, but prior to any adjustments, the flowmeter shall show no deviation greater than plus or minus 5 percent between the total flow accuracy measurements made after the shock test compared to the accuracy test made before shock. After the shock test, the flowmeter shall be calibrated into the original accuracy requirement of 3.4.1 if necessary. There shall be no damage to any part of the flowmeter as a result of the shock test.

3.4.13 Production screening. There shall be no evidence of damage to the flowmeter equipment (see 4.8.2).

3.4.14 Electromagnetic susceptibility and emission control. Flowmeter equipment shall meet the following requirements of MIL-STD-461: CE01, CE03, CS01, CS02, CS06, CS09, RE01, RE02, RS01, RS02, RS03, except as modified below:

(a) Requirement CS02 shall be met as specified except as follows:

- (1) At frequencies between 2 and 30 megahertz (MHz), the full output of the generator (source impedance of 50 ohms, and an output capability of 12.25 volts root mean square (Vrms), or 3 watts, when connected to a 50-ohm load) shall be applied to all power and signal leads of the test sample.

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- (2) The calibrating resistor, or 50-ohm load, shown in the CS02 test block diagram of MIL-STD-462, shall not be connected during the test.

(b) Requirement RS03 shall be met as specified except as follows:

- (1) Between the frequencies of 14 kilohertz (kHz) and 18 gigahertz (GHz), the electric field strength test level shall be 10 volts per meter (V/m).

3.4.14.1 Susceptibility. There shall be no deviation in effective readouts of the equipment when the electromagnetic interference (EMI) generator is on greater than 1 percent or 20 pounds, whichever is greater, compared to a similar readout when the EMI generator is off (see 4.8.16).

3.4.14.2 Emissions. Emissions from the flowmeter equipment shall be within the requirements of MIL-STD-461 for the tests specified in 3.4.14, (see 4.8.16).

3.4.15 Digital readout toggling. The digital readouts shall be such that toggling between any two least significant or other digits shall not take place with any steady state flow input. As an alternative, a time delay of at least $1/2 \pm 30$ percent seconds may be employed for changes in the readout so that, if the LED readout is toggling between two adjacent numbers, each number may be read and the user of the equipment will be able to determine that the actual flow amount is midway between the two least significant digit values being so alternately displayed.

3.4.16 Leakage current. The flowmeter equipment shall meet the leakage current requirements of MIL-E-16400 (see 4.8.18).

3.4.17 Duty cycle. The flowmeter shall meet all the requirements of this specification when operated continuously with ac power constantly applied.

3.5 Reliability. The flowmeter equipment actual mean time between failures (MTBF) shall be at least 9000 hours. The MTBF shall be verified in accordance with 4.8.17.

3.6 Maintenance. The flowmeter equipment shall facilitate disassembly, assembly, location of trouble sources and calibration and maintenance without the aid of special tools. Special tools are defined as those tools not listed in the Federal supply catalog (copies of this catalog may be consulted in the office of the Defense Contract Administration Services Management Area (DCASMA)). Parts such as resistors, capacitors, relays, semiconductor devices, integrated or hybrid circuits and subassemblies such as power supplies and printed circuit boards shall be readily identifiable, accessible and removable for replacement. For purposes of maintenance and calibration, no mechanical or electrical disassembly shall be required for the purpose of obtaining access to calibration controls, control point adjustments (if required) and test points, except for opening an access door or removal of a cover plate.

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3.6.1 Program. When specified in the contract or order (see 6.2.1), the manufacturer shall perform the maintainability tasks in accordance with MIL-STD-470. Logistic support analysis data sheets, where required, shall be in accordance with MIL-STD-1388.

3.6.2 Repair times. Various repair times may apply to the failure modes, but the 90 percentile total repair time for a maintenance event shall not exceed 2.0 hours and the mean time to repair (MTTR) shall not exceed 1.5 hours. Time to repair includes preparation, fault location, fault correction, check out, and other subdivisions as required but does not include logistic time or administrative time.

3.6.3 Level of repair (LOR). Maintenance actions shall be accomplishable by no more than one enlisted repair technician of a grade no higher than E-4.

3.6.4 Maintainability demonstration.

3.6.4.1 Minimum requirements. The contractor shall demonstrate a viable (to an E4 grade technician level) means for troubleshooting any of up to 10 parts of the equipment selected by NAVSEA (or its designated representative) which shall be considered to have failed. The mean time required to remove and replace six parts selected by NAVSEA or its designated representative shall be measured by actual removal and replacement of these parts, one at a time, by an E4 grade technician or equivalent level person who has been instructed by the contractor (previous to the removal and replacement time). In lieu of months of experience with the equipment, the E4 grade or equivalent person shall be instructed just prior to the removal and replacement effort for each part, but not during the actual removal and replacement. The mean time to remove and replace, measured as specified above, shall not exceed 0.8 of the MTTR specified in 3.6.2. The equipment shall work, in reference to the replaced part, after each removal and replacement. The time required to prove the equipment works shall not be included in the remove and replace time measurements.

3.6.4.2 Optional maintainability demonstration. When specified in the contract or order (see 6.2.1), a maintainability demonstration shall be performed in accordance with MIL-STD-471. In this case, the minimum requirements of 3.6.4.1 may be waived by the contract or order (see 6.2.1).

3.6.5 Preventive maintenance interval. The manufacturer of the equipment shall suggest the periodic time interval between preventive maintenance actions and what these actions should be.

3.7 Drawings. When specified in the contract or order, drawings shall be prepared (see 6.2.2).

3.8 Workmanship. Workmanship shall be in accordance with requirement 9 of MIL-STD-454. The flowmeter equipment covered by this specification shall meet the needs of Naval shipboard service, reflect the maximum simplicity and reliability consistent with the state-of-the-art and be easy to install and maintain. The flowmeter equipment shall be in accordance with MIL-E-16400 to the extent specified herein.

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4. QUALITY ASSURANCE PROVISIONS

4.1 Responsibility for inspection. Unless otherwise specified in the contract or purchase order, the contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified in the contract or purchase order, the contractor may use his own or any other facilities suitable for the performance of the inspection requirements specified herein, unless disapproved by the Government. The Government reserves the right to perform any of the inspections set forth in the specification where such inspections are deemed necessary to assure supplies and services conform to prescribed requirements.

4.1.1 Responsibility for compliance. All items must meet all requirements of sections 3 and 5. The inspection set forth in this specification shall become a part of the contractor's overall inspection system or quality program. The absence of any inspection requirements in the specification shall not relieve the contractor of the responsibility of assuring that all products or supplies submitted to the Government for acceptance comply with all requirements of the contract. Sampling in quality conformance does not authorize submission of known defective material, either indicated or actual, nor does it commit the Government to acceptance of defective material.

4.1.2 Test equipment and inspection facilities. Test and measuring equipment and inspection facilities of sufficient accuracy, quality and quantity to permit performance of the required inspections shall be established and maintained by the contractor in accordance with MIL-STD-45662. When specified in the contract or order, a calibration system shall be prepared (see 6.2.2).

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

- (a) First article inspection (see 4.4).
- (b) Quality conformance inspection (see 4.5).

4.3 Inspection conditions. Unless otherwise specified herein, all inspections shall be performed in accordance with the test conditions specified in MIL-STD-202.

4.3.1 Equipment configuration. The worst case equipment configuration shall be used for all tests. For example, if a flowmeter equipment is to work with interconnecting cable between transducer and signal conditioner of lengths varying from 10 to 100 feet, and longer lengths are worst case, then 100 feet of cable shall be used.

4.4 First article inspection. The sample shall be subjected to the inspections specified in table I. The inspections shall be performed in the sequence shown except for the reliability demonstration, which may be performed on other flowmeter equipments prior to, concurrent with, or after the other first article inspections. When specified in the contract or order, a first article inspection procedure and report shall be prepared (see 6.2.2).

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4.4.1 Sampling for first article inspection. One flowmeter equipment of each type shall be subjected to first article inspection. A change in range (by scale plug-in card change, for example) shall not require more than one sample to be tested except for transducers of different size (see 4.4.1.1) providing each scale card has the same type construction and only circuit values are different, or providing that circuit configuration differences are minor with respect to the first article tests. First article samples that have passed first article inspection shall not be considered for shipboard installation.

4.4.1.1 Transducer sample. Where one flowmeter flow computer works with more than one size (pipe) or liquid and transducers are therefore of different size or type, each size or type transducer shall be tested.

TABLE I. First article inspections.

Inspection	Requirement	Inspection
All quality conformance inspections for group A (see table II).		
Accuracy	3.4.1	4.8.1
Repeatability	3.4.2	4.8.4
Inclination	3.4.4	4.8.5
Digital readout toggling	3.4.15	4.8.6
Enclosure	3.5.13.2	4.8.7
Salt fog	3.4.9	4.8.8
Warm-up time	3.4.3	4.8.9
Temperature	3.4.7	4.8.10
Supply voltage and frequency (steady state)	3.4.5	4.8.11
Supply voltage and frequency (transients)	3.4.6	4.8.12
Humidity	3.4.8	4.8.13
Insulation resistance	3.4.10	4.8.3
Leakage current	3.4.16	4.8.18
Vibration	3.4.11	4.8.14
Shock	3.4.12	4.8.15
EMI	3.4.14.1	4.8.16
Reliability demonstration	3.5	4.8.17

4.5 Quality conformance inspection. Quality conformance inspection shall be as specified in table II. When specified in the contract or order, a test report shall be prepared (see 6.2.2).

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TABLE II. Quality conformance inspections.

Inspection	Requirement	Inspection
<u>Group A</u>		
General examination	3.2, 3.3, 3.3.9, 3.3.10, 3.3.12, 3.3.13, 3.3.14	4.6
Accuracy	3.4.1	4.8.1
Production screening	3.4.13	4.8.2
Insulation resistance	3.4.10	4.8.3
Accuracy (static error band and repeatability)	3.4.1 3.4.2	4.8.1 4.8.4
<u>Group B</u>		
Supply voltage and fre- quency (steady state)	3.4.5	4.8.11
Temperature	3.4.7	4.8.10
Insulation resistance	3.4.10	4.8.3
Accuracy	3.4.1	4.8.1
<u>Group C</u>		
Those inspections, as determined by NAVSEA, chosen from the first article inspections (see table I) whose outcome may be affected by the changes to the equipment shall be repeated for group C inspections. If the changes to the equipment are deemed sufficiently extensive by NAVSEA, all of the first article tests of table I may be specified by NAVSEA for group C inspection.		

4.5.1 Inspection lot. An inspection lot shall consist of all flowmeter equipment of each type (type of construction) produced under essentially the same conditions and offered for inspection at the same time.

4.5.1.1 Group A inspection. Each equipment in a lot shall be subjected to the group A inspections specified in table II. Equipment that fails any test may be corrected and retested, except that no special selection of components may be used. Any equipment or parts of equipment so corrected or reworked shall be submitted to the contracting activity or its representative for approval before being reinstalled in the equipment. Equipment so corrected shall be retested for all group A quality conformance tests.

4.5.1.2 Group B inspection. A random sample shall be selected from each lot to be delivered that has satisfactorily passed the group A tests and shall be subjected to the group B inspections specified in table II to determine conformance with this specification. The sampling procedures shall be in accordance with MIL-STD-105, with an acceptable quality level (AQL) of 1.0. Initial acquisitions shall be given a normal inspection level II. Continuation of inspection levels shall be in accordance with MIL-STD-105. If the number of

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nonconforming equipment equals the rejection number specified in MIL-STD-105, the lot shall be rejected. Nonconforming equipment may be corrected except that no special selection of components may be used. Any equipment or parts of equipment so corrected or reworked shall be submitted to the contracting activity or its representative for approval before being reinstalled in the equipment. Corrected equipment shall be retested for all quality conformance tests except group C. Sample units which have passed the group B inspections may be delivered if the lot is accepted and the units have suffered no damage due to handling, storage, testing or any other source.

4.5.1.3 Group C inspections. Group C inspections in accordance with table II shall be conducted when the basic construction of the equipment or the material of a vital part has been changed. One complete flowmeter equipment shall be randomly selected and subjected to the group C inspections specified in table II. Group C inspections shall be made on a sample unit which has passed the groups A and B inspections. The sample unit which has been subjected to group C inspections, shall not be delivered on the contract. If the sample unit fails to pass any of group C inspections, the sample shall be considered to have failed and the lot represented by the sample shall be rejected until corrective action is taken as follows: the testing agency or supplier of the equipment shall notify NAVSEA and the purchaser of such failure and take corrective action on the materials or processes, or both, as warranted and on all units of the lot which can be corrected. Acceptance and shipment of the product shall be discontinued until corrective action acceptable to NAVSEA has been taken. After corrective action has been taken, tests selected by NAVSEA from groups A, B and C and those tests of group C which the test sample has failed shall be re-performed. In the event of failure after re-inspection, information concerning the failure shall be furnished to NAVSEA and the prospective purchaser of the equipment.

4.6 General examination. The flowmeter equipment shall be examined to determine conformance to the requirements of this specification with respect to material, color, finish, workmanship, safety, construction, assembly, dimensions, weight, and marking of identification and information plates. Examination shall be limited to the examinations that may be performed without disassembling the unit in such a manner that its performance, durability, or appearance would be affected. Examination shall also include a check of all operation controls and maintenance adjustments, as applicable.

4.7 Test conditions and test apparatus accuracy.

4.7.1 Test conditions. Except where the following factors are the variables, the tests specified in 4.8 shall be conducted with the equipment operating under the following conditions:

- (a) Ambient temperature shall be $75 \pm 10^{\circ}\text{F}$.
- (b) Relative humidity shall be 60 ± 30 percent.
- (c) Supply voltage shall be nominal.
- (d) Supply frequency shall be nominal (as applicable).
- (e) Controls shall be in the neutral or normal position.

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4.7.2 Test apparatus accuracy. The accuracy of instruments and test equipment used to control and monitor the test parameters shall be in accordance with MIL-E-16400.

4.8 Tests. The flowmeter equipment and all associated test equipment shall be energized for a period of time to ensure complete warm-up except during the warm-up test. The flowmeter equipment shall be energized for all tests except where specified not to be energized.

4.8.1 Accuracy. The accuracy (calibration) of the flowmeter under test shall be tested at 0, 1/3 (plus or minus 5 percent), 2/3 (plus or minus 5 percent) and full scale (minus 5 percent) of the flow rate range specified in 3.3.9.4. The period of integration for total flow shall be 5 minutes or less but, except at zero flow, sufficient to yield at least 4000 pounds of liquid transfer or as specified by NAVSEA. Bi-directional flowmeters shall be tested as above in both directions.

4.8.2 Production screening. The flowmeter equipment under test shall be subjected to the following temperature and vibration tests in accordance with MIL-STD-167-1. The accuracy test (see 4.8.1) shall be conducted immediately following these tests and the results shall be in accordance with 3.4.1 and 3.4.13.

4.8.2.1 Temperature cycling. With the unpowered flowmeter equipment installed in the temperature chamber, the equipment under test shall be subjected to three temperature cycles: Each cycle shall be from $75 \pm 9^{\circ}\text{F}$ to $65 \pm 4^{\circ}\text{F}$ to $158 \pm 4^{\circ}\text{F}$ and back to $75 \pm 9^{\circ}\text{F}$. The rate of temperature change shall be $20 \pm 10^{\circ}\text{F}$ per minute. A soak time of at least 30 minutes at each temperature extreme of each cycle shall be provided. After the specified number of cycles have been completed and the equipment is returned to room temperature for at least 10 minutes, the unit shall be powered and calibration shall be checked at zero flow, and any self-test feature that may be provided shall be actuated. The unit shall meet the accuracy requirement for zero flow (see 3.4.1) and pass the self-test.

4.8.2.2 Random vibration. The flowmeter equipment under test shall be energized during the random vibration. The equipment under test shall be mounted on the test fixture so that the axis of vibration is perpendicular to the plane of the printed circuit boards. The duration of the vibration shall be 10 minutes. The nature of the vibration and the spectrum shall be in accordance with MIL-STD-167-1.

4.8.3 Insulation resistance. The insulation resistance of the flowmeter equipment under test shall be determined by applying 50 volts direct current between insulated inputs including power inputs and ground and between insulated outputs and ground (providing the input or output will not be harmed by the 50 volts) and measuring transient current flow. Insulation resistance shall meet the requirements specified in 3.4.10.

4.8.4 Repeatability. The accuracy test of 4.8.1 shall be performed at least three times with the actual total flow measurement points controlled or determined to an accuracy at least three times better than the allowed error in repeatability. The repeatability shall meet the requirements specified in 3.4.2.

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4.8.5 Inclination. The flowmeter and its subunits under test, excluding the transducer, shall be tested for accuracy in each of the following inclinations:

- (a) 60 degrees from vertical forward.
- (b) 60 degrees from vertical backward.
- (c) 60 degrees from vertical to the left.
- (d) 60 degrees from vertical to the right.
- (e) Normal, horizontal position.

The flowmeter shall meet the requirements specified in 3.4.1 and 3.4.2.

4.8.6 Digital readout toggling. The accuracy test of 4.8.1 shall be performed, except that at each total flow specified flow shall be stopped and then increased (and decreased if necessary) very slowly so as to spend approximately 2 minutes at flow totals between least significant digits on totalizer digital electronic readouts. The toggling, if any, back and forth between successive readouts shall meet the requirements specified in 3.4.15.

4.8.7 Enclosure. The flowmeter equipment shall be subjected to the splash-proof test specified in MIL-STD-108. Performance shall be in accordance with 3.3.13.2.

4.8.8 Salt fog. The flowmeter equipment shall be subjected to the salt fog test specified in MIL-STD-810, method 509.2, procedure I. Performance shall be in accordance with 3.4.9.

4.8.9 Warm-up time. The unpowered flowmeter equipment shall be held at the lower limit of the specified ambient operating temperature range of this specification for a period of at least 2 hours. After the 2 hours, a liquid flow of $2/3 \pm 5$ percent of range shall be initiated and maintained and then the power turned on. The warm-up time requirement of 3.4.3 shall be met.

4.8.10 Temperature. The flowmeter equipment shall be subjected to the following environmental temperature tests.

4.8.10.1 Fluid temperature tests. With the transducer mounted on a test pipe in a flow test stand, the complete flowmeter shall be tested for accuracy in accordance with 4.8.1 at the minimum and maximum liquid temperatures specified in 3.3.9.3 after a minimum stabilization period of 30 minutes at each fluid temperature.

4.8.10.2 Ambient environmental temperature tests. The flowmeter equipment shall be subjected to the operating and non-operating environmental temperature test sequence specified in MIL-E-16400 for temperature range 4 (sheltered controlled environment, (ship or shore)) equipment except that the upper limit of the operating temperature range shall be 140°F . The equipment shall meet the requirements of 3.4.7.

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4.8.11 Supply voltage and frequency (steady state). The flowmeter equipment shall be stabilized for at least 30 minutes prior to any measurements at $32 \pm 4^\circ\text{F}$, $75 \pm 10^\circ\text{F}$ and $140 \pm 5^\circ\text{F}$. At each of these temperatures, the accuracy measurements of 4.8.1 shall be performed at each of the following nominal, maximum and minimum supply steady state conditions listed below. The temperature shall be varied in steps of $20 \pm 3^\circ\text{F}$ at 30 minutes per step until the desired ambient is reached. The results shall meet the requirements of 3.4.5.

<u>Voltage</u>	<u>Frequency (Hz)</u>
115	60
123	62
107	62
107	58
123	58

4.8.12 Supply voltage and frequency (transients). The voltage and frequency transients tests shall be conducted with the flowmeter under test configured in the normal flow measurement mode and with the average flow velocity adjusted to 60 ± 10 percent of range. A reference total flow measurement shall be made at nominal voltage and frequency over a 5 ± 0.5 minute integration period to be used as a standard for comparison against similar measurements which include transient tests specified as follows.

4.8.12.1 Voltage transient (type I power). Performance shall be as specified in 3.4.6.1.

4.8.12.1.1 Positive transient. The reference measurement specified in 4.8.12 shall be repeated with an actual total flow within plus or minus 0.2 percent of the actual total flow of the reference measurement except that the supply voltage shall be 4 percent above the nominal steady state voltage throughout the integration period and a transient voltage of plus 16 ± 3 percent of nominal shall be superimposed recovering to the initial voltage in 2 ± 10 percent seconds. The transient shall be applied at the halfway point (2.5 ± 0.5 minutes) of the integration period.

4.8.12.1.2 Negative transient. The reference measurement specified in 4.8.12 shall be repeated as in 4.8.12.1.1, except that the supply voltage shall be 4 percent below nominal throughout the integration period and a transient voltage of minus 16 ± 3 percent of nominal shall be superimposed recovering to the initial voltage in 2 ± 0.25 seconds. The transient shall be applied at the halfway point (2.5 ± 0.5 minutes) of the integration period.

4.8.12.2 Frequency transients. Performance shall conform to 3.4.6.2 for each test specified in 4.8.12.2.1 and 4.8.12.2.2.

4.8.12.2.1 Positive transient. The reference measurement of 4.8.12 shall be repeated, with an actual flow within 0.2 percent of the actual total flow of the reference measurement except that the supply frequency shall be 1.5 percent above the nominal steady state frequency (60 Hz) and a transient frequency increase of plus 4 percent of nominal shall be superimposed recovering to the initial frequency in 2 ± 0.25 seconds. The transient shall be applied at the halfway point (2.5 ± 0.5 minutes) of the integration period.

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4.8.12.2.2 Negative transient. The reference measurement of 4.8.12 shall be repeated as specified in 4.8.12.2.1 except that the supply frequency shall be 1.5 percent below the nominal steady state frequency (60 Hz) and a transient frequency change of minus 4 percent of nominal shall be superimposed recovering to the initial frequency in 2 ± 0.25 seconds. The transient shall be applied at the halfway point (2.5 ± 0.5 minutes) of the integration period.

4.8.12.3 Spike voltage. The flowmeter equipment shall be subjected to the spike voltage test of MIL-E-16400. The performance shall conform to 3.4.6.3.

4.8.13 Humidity. The flowmeter equipment shall be subjected to the humidity test of MIL-STD-810, method 507.2, procedure III, except that step 6 shall be changed from 10 cycles to 5 cycles. Whenever MIL-STD-810, method 507.2 calls for an operational check, the accuracy calibration of 4.8.1 shall be performed.

4.8.14 Vibration. The flowmeter equipment under test shall be tested in accordance with type I (environmental vibration) of MIL-STD-167-1. If no resonances are observed, the 2-hour endurance test of MIL-STD-167-1 shall be conducted at 50 Hz. During the vibration test, the flowmeter shall be operating (power on) and zero flow condition (for feasibility of test) shall be maintained. Flowmeter readouts shall be monitored periodically during the test to ascertain the readouts do not change by more than one least significant digit during the test. After the test, an accuracy measurement in accordance with 4.8.1 shall be performed and performance shall conform to 3.4.11.

4.8.15 Shock. Prior to the shock test, a total flow accuracy test at 65 ± 10 percent flow and integration period of at least 5 minutes shall be conducted and results recorded. This test shall be repeatable with an actual flow total repeatable to plus or minus 0.4 percent. The flowmeter shall then be subjected to a shock test in accordance with grade A, class I, type A test of MIL-S-901. For feasibility of test, a zero flow condition can be maintained to the flowmeter transducer at the tester's option. After the shock tests are completed, the accuracy test shall be repeated with an actual total flow accuracy of plus or minus 0.4 percent. No adjustment shall be made to the flowmeter. The performance of the flowmeter shall conform to the requirements of 3.4.12.

4.8.16 EMI tests. When subjected to the tests specified in MIL-STD-462, modified as specified in 3.4.14, the flowmeter shall meet the requirements of 3.4.14.

4.8.16.1 Susceptibility testing criteria. The test for susceptibility to EMI shall have the flowmeter measure actual flow of 60 ± 10 percent of range in a test pipe and check for deviation in flow readout when the EMI generator is turned on compared to the same measurement where the EMI generator is off.

4.8.16.2 Emission testing. Emission tests shall be conducted with the flowmeter operating and the transducer installed on a test section of pipe. Actual flow shall be through the pipe in order to produce changes in the digital readouts.

4.8.17 Reliability verification. Reliability of the equipment shall be verified by the method of 4.8.17.1 or 4.8.17.2 as specified in the contract or order (see 6.2.1).

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4.8.17.1 Reliability demonstration. MTBF shall be demonstrated in a test program of statistically valid length using test plan IVC or XIVC of MIL-STD-781. The lower test MTBF (θ) shall be 9,000 hours and the upper test MTBF (θ) shall be 18,000 hours for consumer's risk (β) and producer's risk (α) of 0.2. θ_1 , θ_0 , β , and α shall be as specified in MIL-STD-781.

4.8.17.2 Reliability prediction. Total equipment MTBF shall be verified by a reliability prediction in accordance with MIL-HDBK-217, EFRD-1 and MIL-STD-785, task 203, or combinations of the above. In accordance with the "predicted MTBF" definition of MIL-STD-781, the predicted MTBF shall be at least 18,000 hours.

4.8.18 Leakage current. The leakage current between each side of the power line and the equipment enclosure, when measured in accordance with MIL-E-16400, shall meet the requirements of 3.4.16.

4.9 Inspection of packaging. Sample packages and packs, and the inspection of the preservation packing and marking for shipment, stowage and storage shall be in accordance with the requirements of section 5 and the documents specified therein.

5. PACKAGING

(The packaging requirements specified herein apply only for direct Government acquisition. For the extent of applicability of the packaging requirements of referenced documents listed in section 2, see 6.5.)

5.1 Packaging requirements. Liquid flow meters shall be preserved level A, C or commercial, packed level A, B, C, or commercial, and marked in accordance with MIL-E-17555, as specified (see 6.2.1).

(a) Navy fire-retardant requirements

(1) Treated lumber and plywood. Unless otherwise specified (see 6.2.1), all lumber and plywood including laminated veneer material used in shipping containers and pallet construction, members, blocking, bracing, and reinforcing shall be fire-retardant treated material conforming to MIL-L-19140 as follows:

Levels A and B	- Type II - weather resistant.
	Category 1 - general use.
Level C	- Type I - non-weather resistant.
	Category 1 - general use.

(2) Fiberboard. Unless otherwise specified (see 6.2.1), fiberboard used in the construction of class-domestic, non-weather resistant fiberboard, cleated fiberboard boxes including interior packaging forms shall meet the flame spread index and the specific optic density requirements of PPP-F-320 and amendments thereto.

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6. NOTES

6.1 Intended use. The flowmeter equipment covered by this specification provides readouts of total liquid flow and, as an option, flow velocity (see 1.2.2.3) and are intended for use aboard U.S. Navy surface ships and submarines. The flow of the following types of liquids may be measured:

- (a) Sea water.
- (b) Fresh water.
- (c) Fuel oil.
- (d) Hydraulic oil.
- (e) Lube oil.
- (f) Contents of bilge (may be mixture of oils and water).
- (g) Any other liquid as specified in the contract or order.

6.2 Ordering data.

6.2.1 Acquisition requirements. Acquisition documents should specify the following:

- (a) Title, number, and date of this specification.
- (b) The liquid or liquids whose flow is to be measured (see 1.2.2.1 and 3.3.9.2).
- (c) Flow rate range (see 1.2.2.2.1 and 3.3.9.4).
- (d) The number of decimal digits in the flow totalizer readouts (see 1.2.2.2.2, 3.3.10.2 and 3.3.12).
- (e) The inclusion of flow rate meters provided in the specified equipment locations (flow computer, remote readout unit, or both) (see 1.2.2.3 and 3.3.12).
- (f) The number of remote control/readout units, and readouts, indicators and controls details if other than specified (see 1.2.2.4, 3.3.12 and 3.3.12.1).
- (g) Down count capability for reverse flow indication, as well as up count capability of the flow totalizers (see 1.2.2.5).
- (h) Low flow rate exclusion option, and control (see 1.2.2.6 and 3.3.11.1).
- (i) Multiplex data bus option (see 1.2.2.7).
- (j) Quantity of flowmeter equipments required.
- (k) Whether there should be three or more subunits as follows:

- (1) Transducer
- (2) Signal conditioner
- (3) Remote control/readout functions

or whether two or more of these functional units should be combined (see 3.3.1).

- (l) Multiple flowmeters in one equipment, if required, and which, if any, of the remote control/readout functions should also be contained in the associated remote control/readout units (see 3.3.5).
- (m) Special illumination requirements, if any (see 3.3.8).
- (n) Type and size of pipe to which the flowmeter should be attached (see 3.3.9.1).

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- (o) Length of cables between the flow computer and each of the transducer and remote control/readout units, if other than specified (see 3.3.10.1.1 and 3.3.10.1.2).
- (p) Controls and indicators for the signal conditioner (see 3.3.11.4, 3.3.11.5, 3.3.11.6 and 3.3.11.7).
- (q) Special mounting requirements (see 3.3.13.1).
- (r) Miniaturization, if required, and the resulting reduced size, weight and combination of subassemblies of the flowmeter (see 3.3.13.4).
- (s) Maintainability demonstration, if required, and whether minimum requirements of 3.6.4.1 are waived (see 3.6.4.2).
- (t) Maintainability program, if required (see 3.6.1).
- (u) Reliability verification method (see 4.8.17).
- (v) Level of preservation, packing, and marking required (see 5.1).
- (w) When fire retardant requirements are not required (see 5.1(a)).

6.2.2 Data requirements. When this specification is used in an acquisition and data are required to be delivered, the data requirements identified below shall be developed as specified by an approved Data Item Description (DD Form 1664) and delivered in accordance with the approved Contract Data Requirements List (CDRL), incorporated into the contract. When the provisions of DoD FAR Supplement, Part 27, Sub-Part 27.475-1 (DD Form 1423) are invoked and the DD Form 1423 is not used, the data specified below shall be delivered by the contractor in accordance with the contract or purchase order requirements. Deliverable data required by this specification are cited in the following paragraphs.

<u>Paragraph no.</u>	<u>Data requirement title</u>	<u>Applicable DID no.</u>	<u>Option</u>
3.7	Drawings, engineering and associated lists	DI-E-7031	Level 3
4.1.2	Calibration system	DI-R-7064	----
4.4	First article inspection procedure	DI-T-4901	----
4.4	First article inspection report	DI-T-4902	----
4.5	Inspection and test reports	DI-T-5329	----

(Data item descriptions related to this specification, and identified in section 6 will be approved and listed as such in DoD 5010.12-L., AMSDL. Copies of data item descriptions required by the contractors in connection with specific acquisition functions should be obtained from the Naval Publications and Forms Center or as directed by the contracting officer.)

6.2.2.1 The data requirements of 6.2.2 and any task in sections 3, 4, or 5 of this specification required to be performed to meet a data requirement may be waived by the contracting/acquisition activity upon certification by the offeror that identical data were submitted by the offeror and accepted by the Government under a previous contract for identical item acquired to this specification. This does not apply to specific data which may be required for each contract regardless of whether an identical item has been supplied previously (for example, test reports).

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6.2.2.2 Technical manuals. The requirement for technical manuals should be considered when this specification is applied on a contract. If technical manuals are required, Military specifications and standards which have been cleared and listed in DoD 5010.12-L (AMSDL) must be listed on a separate CDRL (DD Form 1423), included as an exhibit to the contract. The technical manuals must be acquired under separate contract line item in the contract.

6.3 First article. When a first article inspection is required, the items should be a first article sample. The first article should consist of one unit. The contracting officer should include specific instructions in acquisition documents regarding arrangements for examinations, approval of first article test results and disposition of first articles. Invitations for bids should provide that the Government reserves the right to waive the requirement for samples for first article inspection to those bidders offering a product which has been previously acquired or tested by the Government, and that bidders offering such products, who wish to rely on such production or test, must furnish evidence with the bid that prior Government approval is presently appropriate for the pending contract.

6.4 Provisioning. Provisioning Technical Documentation (PTD), spare parts, and repair parts should be furnished as specified in the contract.

6.4.1 When ordering spare parts or repair parts for the equipment covered by this specification, the contract should state that such spare parts and repair parts should meet the same requirements and quality assurance provisions as the parts used in the manufacture of the equipment. Packaging for such parts should also be specified.

6.5 Sub-contracted material and parts. The packaging requirements of referenced documents listed in section 2 do not apply when material and parts are acquired by the contractor for incorporation into the equipment and lose their separate identity when the equipment is shipped.

6.6 Subject term (key word) listing.

Multiplex data bus
Remote control/readout unit

Preparing activity:
Navy - SH
(Project 6680-N217)

INSTRUCTIONS: In a continuing effort to make our standardization documents better, the DoD provides this form for use in submitting comments and suggestions for improvements. All users of military standardization documents are invited to provide suggestions. This form may be detached, folded along the lines indicated, taped along the loose edge (*DO NOT STAPLE*), and mailed. In block 5, be as specific as possible about particular problem areas such as wording which required interpretation, was too rigid, restrictive, loose, ambiguous, or was incompatible, and give proposed wording changes which would alleviate the problems. Enter in block 6 any remarks not related to a specific paragraph of the document. If block 7 is filled out, an acknowledgement will be mailed to you within 30 days to let you know that your comments were received and are being considered.

NOTE: This form may not be used to request copies of documents, nor to request waivers, deviations, or clarification of specification requirements on current contracts. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements.

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DEPARTMENT OF THE NAVY
COMMANDER
NAVAL SEA SYSTEMS COMMAND (SEA 5523)
DEPARTMENT OF THE NAVY
WASHINGTON, DC 20362-5101



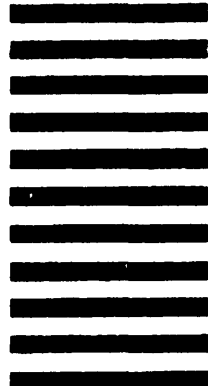
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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions - Reverse Side)

1. DOCUMENT NUMBER MIL-F-24701 (SH)		2. DOCUMENT TITLE FLOWMETER, LIQUID, ULTRASONIC, NON-INTRUSIVE	
3a. NAME OF SUBMITTING ORGANIZATION		4. TYPE OF ORGANIZATION <i>(Mark one)</i> <input type="checkbox"/> VENDOR <input type="checkbox"/> USER <input type="checkbox"/> MANUFACTURER <input type="checkbox"/> OTHER <i>(Specify):</i> _____	
b. ADDRESS <i>(Street, City, State, ZIP Code)</i>			
5. PROBLEM AREAS			
a. Paragraph Number and Wording:			
b. Recommended Wording:			
c. Reason/Rationale for Recommendation			
6. REMARKS			
7a. NAME OF SUBMITTER <i>(Last, First, MI) - Optional</i>		b. WORK TELEPHONE NUMBER <i>(Include Area Code) - Optional</i>	
c. MAILING ADDRESS <i>(Street, City, State, ZIP Code) - Optional</i>		8. DATE OF SUBMISSION <i>(YYMMDD)</i>	