INCH-POUND
MIL-M-24144D(SH)
25 April 1988
SUPERSEDING
MIL-I-24144C(SHIPS)
30 June 1978
(See 6.7)

MILITARY SPECIFICATION

MONITORS, FROST-POINT/DEW-POINT, COMPRESSED AIR, SEMI-PORTABLE

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 semi-portable frost/dew point monitors used to determine the moisture content of shipboard compressed air systems.

1.2 Classification. Monitors shall be of the following types and pressure ranges as specified.

1.2.1 Type. Monitor types shall be as follows:

Chilled surface monitor (CSM) - dew point temperature determined by visual or automatic detection of vapor condensation on a chilled mirror surface exposed to sample air (see 6.2).

Direct reading hygrometer (DRH) - dew point temperature determined by measuring the electrical properties of a sensing device exposed to sample air (see 6.2).

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 55Z3, 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.

AMSC N/A FSC 6685

1.2.2 Pressure ranges. Pressure ranges for either type shall be as follows:

Low pressure (LP) - 1 to 150 pounds per square inch (lb/in^2).
High pressure (HP) - 3,000 to 5,000 lb/in^2 (see 6.2).

2. APPLICABLE DOCUMENTS

2.1 Government documents.

2.1.1 Specifications and standards. The following specifications and standards 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.

MILITARY

MIL-S-901 - Shock Tests, H.I. (High-Impact); Shipboard Machinery, Equipment and Systems, Requirements for.
MIL-S-3786 - Switches, Rotary (Circuit Selector, Low-Current Capacity), General Specification for.
MIL-S-3950 - Switches, Toggle, Environmentally Sealed, General Specification for.
MIL-B-5423 - Boots, Dust and Water Seal (for Toggle and Push-button Switches, Circuit Breakers, and Rotary-Actuated Parts), General Specification for.
MIL-C-5541 - Chemical Conversion Coatings on Aluminum and Aluminum Alloys.
MIL-S-8805 - Switches and Switch Assemblies, Sensitive and Push (Snap Action), General Specification for.
MIL-F-15160 - Fuses: Instrument, Power, and Telephone.
MIL-S-15291 - Switches, Rotary, Snap Action and Detent/Spring Return Action, General Specification for.
MIL-S-15743 - Switches, Rotary, Enclosed.
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-G-18997 - Gauge, Pressure, Dial Indicating.

MILITARY (Continued)

MIL-L-19140 - Lumber and Plywood, Fire-Retardant Treated.
MIL-F-19207 - Fuseholders, Extractor Post Type, Blown Fuse Indicating and Nonindicating General Specification for.
MIL-F-19207/1 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL10U and FHL10G.
MIL-F-19207/2 - Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL11U and FHL11G.
MIL-S-22710 - Switches, Rotary (Printed Circuit), (Thumbwheel, Inline, and Pushbutton), General Specification for.
MIL-S-22885 - Switches, Pushbutton, Illuminated, General Specification for.
MIL-P-24212 - Pressure Transducer Equipment (Electrical).
MIL-M-38510 - Microcircuits, General Specification for.
MIL-S-55433 - Switches, Reed, General Specification for.
MIL-R-83248 - Rubber, Fluorocarbon Elastomer, High Temperature, Fluid, and Compression Set Resistant.

STANDARDS

FEDERAL

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

MILITARY

MIL-STD-105 - Sampling Procedures and Tables for Inspection by Attributes.
MIL-STD-167-1 - Mechanical Vibrations of Shipboard Equipment (Type I - Environmental and Type II - Internally Excited).
MIL-STD-275 - Printed Wiring for Electronic Equipment.
MIL-STD-278 - Welding and Casting Standard.
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.
DOD-STD-1399, Section 300 - Interface Standard for Shipboard Systems, Electric Power, Alternating Current. (Metric)
DOD-STD-2142 - Magnetic Silencing Characteristics, Measurement of. (Metric)
DOD-STD-2143 - Magnetic Silencing Requirements for the Construction of Nonmagnetic Ships and Craft. (Metric)

2.1.2 Other Government publication. The following other Government publication forms a part of this specification to the extent specified herein. Unless otherwise specified, the issues shall be those in effect on the date of the solicitation.

PUBLICATION

NAVAL SEA SYSTEMS COMMAND (NAVSEA)

0900-LP-001-7000 - Fabrication and Inspection of Brazed Piping Systems.

(Copies of specifications, standards, and publications 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 Other publications. The following documents form a part of this specification to the extent specified herein. Unless otherwise specified, the issues of the documents which are DoD adopted shall be those listed in the issue of the DoDISS specified in the solicitation. Unless otherwise specified, the issues of documents not listed in the DoDISS shall be the issue of the nongovernment documents which is current on the date of the solicitation.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

A 167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip. (DoD adopted)

A 213 - Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes. (DoD adopted)

A 269 - Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service. (DoD adopted)

A 276 - Standard Specification for Stainless and Heat-Resisting Steel Bars and Shapes. (DoD adopted)

B 21 - Standard Specification for Naval Brass Rod, Bar, and Shapes (Metric). (DoD adopted)

B 75 - Standard Specification for Seamless Copper Tube. (DoD adopted)

B 111 - Standard Specification for Copper and Copper-Alloy Seamless Condenser Tubes and Ferrule Stock. (DoD adopted)

B 135 - Standard Specification for Seamless Brass Tube. (DoD adopted)

B 221 - Standard Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Shapes, and Tubes. (DoD adopted)

D 702 - Standard Specification for Cast Methacrylate Plastic Sheets, Rods, Tubes, and Shapes. (DoD adopted)

(Application for copies should be addressed to the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.)

(Nongovernment standards and other publications are normally available from the organizations which prepare or which distribute the documents. These documents also may be available in or through libraries or other informational services.)

2.3 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.

3. REQUIREMENTS

3.1 Qualification. Monitors furnished under this specification shall be products which are authorized by the qualifying activity for listing on the applicable qualified products list at the time set for opening of bids (see 4.3 and 6.3).

3.2 Materials. Monitor parts shall have materials in accordance with DOD-STD-2143 and table I or table II. Chemically equivalent metal materials may be substituted as long as physical and chemical characteristics are similar. Items and parts used in the monitors shall be new and unused. Reclaimed material shall be used to the maximum extent practicable in producing such items and parts provided that the monitors' items and parts conform to the requirements of this specification. To insure minimal operator hazards when using the monitors, safety considerations shall be exercised where selecting component material.

TABLE I. Material requirements for CSM.

Item	Material	Applicable documents	Remarks
Heat exchanger tubing	Copper Copper-nickel	ASTM B 111 ASTM B 111	Applicable to LP and HP configuration
	Corrosion-resisting steel	ASTM A 213 (grade TP 316)	
Heat exchanger shell	Corrosion-resisting steel	ASTM A 213 (grade TP 316)	Applicable to LP and HP configuration
Sampling chamber	Corrosion-resisting steel	ASTM A 276 (type 316) ASTM A 167 (type 316)	Material applicable to HP or LP material as accepted

TABLE I. Material requirements for CSM. - Continued

Item	Material	Applicable documents	Remarks
Heat sink with precipitating surface (mirror) finish	Copper	ASTM B 75	Applicable to LP and HP configuration
	Chrome-nickel alloy		Mirror finish of chrome-nickel alloy plated on copper heat sink
Viewer window	Colorless, transparent cast acrylic (methyl-methacrylate)	ASTM D 702 (type III, grade 1)	Applicable to LP and HP configuration
Valves	Corrosion-resisting steel - 300 series		Material applicable to HP or LP material as accepted
Pressure tubing (excluding heat exchanger)	Corrosion-resisting steel	ASTM A 269 (grade TP 316)	Material applicable to HP or LP material as accepted
Indicator case (LP and HP)	Aluminum on high impact ABS plastic	ASTM B 221	Aluminum material shall be treated against corrosion by anodizing or in accordance with MIL-C-5541
Sampling tube, armor, adaptors, and connections	Corrosion-resisting steel	ASTM A 276, ASTM A 269 (TP 304 or grade TP 316 corrosion-resisting steel)	Applicable to LP and HP configuration
Vortex tube	Corrosion-resisting steel	ASTM A 269 (type 304)	Material applicable to LP configuration
	Brass (rod and bar)	ASTM B 21	
	Brass (seamless tube)	ASTM B 135	

TABLE II. Material requirements for DRH.

Item	Material	Applicable documents	Remarks
Sample cell	Corrosion-resisting steel	ASTM A 276 (type 316) ASTM A 167 (type 316)	Material applicable to HP or LP material as accepted
Valves	Corrosion-resisting steel - 300 series		Applicable to LP and HP configuration
Sampling tube, armor, adaptors, and connections	Corrosion-resisting steel	ASTM A 276, ASTM A 269 (304 or grade TP 316 corrosion-resisting steel)	Applicable to LP and HP configuration
Indicator case (LP and HP)	Aluminum or high impact ABS plastic	ASTM B 221	Aluminum material shall be treated against corrosion by anodizing or in accordance with MIL-C-5441
Pneumatic tubing	Corrosion-resisting steel	ASTM A 269 (grade TP 316)	Material applicable to HP or LP material as accepted

3.2.1 Recovered materials. Unless otherwise specified herein, all equipment, material, and articles incorporated in the products covered by this specification shall be new and may be fabricated using materials produced from recovered materials to the maximum extent practicable without jeopardizing the intended use. The term "recovered materials" means materials which have been collected or recovered from solid waste and reprocessed to become a source of raw materials, as opposed to virgin raw materials. None of the above shall be interpreted to mean that the use of used or rebuilt products is allowed under this specification unless otherwise specifically specified.

3.3 General description. Monitors shall meet the general requirements specified in 3.3.1 through 3.3.4.2.

3.3.1 CSM, low pressure.

3.3.1.1 Construction. Monitors shall consist of, but need not be limited to, the following components.

(a) Heat exchangers.
(b) Sample chamber with viewing window.
(c) Precipitating surface (mirror).
(d) Flow switching valves.
(e) Sample and coolant tubing.
(f) Thermocouples or other electrical temperature sensors.
(g) Digital temperature indicator.
(h) Monitor case.
(i) Sample and coolant connections.
(j) Vortex tube.
(k) Sample flowmeter and flow control valve.
(l) Mirror temperature control.
(m) Optical viewing assembly.
(n) Pressure transducer.
(o) Mirror temperature control valve.
(p) Filter to protect vortex and cryostat.
(q) Electrical power cable and plug.

3.3.1.2 Operational requirements. The monitor shall be constructed so that by connecting the coolant inlet to a sample gas pressure source of 80 to 150 lb/in^2 and the power cable to a 115 volt, 60 hertz (Hz), single-phase, grounded receptacle, it shall be ready for operation. In the event the sample gas pressure is lower than 80 lb/in^2, it shall be connected to the sample gas inlet and an auxiliary coolant gas source (air or nitrogen) of 80 to 150 lb/in^2 shall be supplied to the coolant inlet. Valving shall be provided to isolate the sample chamber from the auxiliary coolant gas and to connect the sample gas to the sample chamber when operating with auxiliary coolant. The monitor shall cool the sample gas to its frost/dew-point by utilizing the cold effluent from a vortex tube and shall provide a convenient method for observing the precipitating surface through the optical viewing assembly. A temperature control valve shall be provided to control the rate of cool-down of the mirror and chamber. The monitor shall incorporate an optical viewing assembly, a precipitating surface, and a sample chamber window arranged to positively ensure that the formation of frost/dew precipitation is clearly distinguishable. Frost/dew precipitation shall occur only on the precipitation surface and spread radially outward with continued cooling of that surface. The monitor shall accurately measure the sample dew point temperature between plus 50 and minus 50 degrees Fahrenheit (°F) while operating at an ambient temperature of 70 ± 5°F. Means shall be provided for the operator to manually freeze the temperature display at any point during the cool-down cycle. The monitor shall also incorporate a means to ensure that precipitation does not become deposited on the outside surface of the windows, window nut, or sampling chamber during operation.

3.3.2 CSM, high pressure. High pressure CSMs shall be as specified in 3.3.2.1 and 3.3.2.2.

3.3.2.1 Components. Monitors shall consist of, but not be limited to, the following components.

(a) Heat exchangers.
(b) Sample chamber with viewing window.
(c) Optical viewing assembly.
(d) Precipitating surface (mirror).
(e) Blowdown valve.
(f) HP tubing.
(g) Thermocouples or other electrical temperature sensors.
(h) Digital temperature indicator.
(i) Monitor case.
(j) Sample gas connection.
(k) Mirror temperature control valve.
(l) Sample flowmeter and flow control valve.
(m) Electrical power cable and plug.
(n) Filter.

3.3.2.2 Operational requirements. The monitor shall be constructed so that by connecting it to a sample gas of 3000 to 5000 lb/in^2 pressure, and 115 volt, 60 Hz, single-phase grounded electrical receptacle, it shall be ready for operation. The monitor shall cool the gas by utilizing the energy of the expanding HP gas as it leaves the sampling chamber and shall provide a method for observing the frost/dew precipitation on the precipitating surface through the optical viewing assembly. The monitor shall incorporate an optical viewing assembly, a precipitating surface, and a sample chamber window constructed and arranged to positively ensure that the formation of frost/dew point precipitation shall be clearly distinguishable. Frost/dew point precipitation shall occur only on the precipitation surface at the location surrounding the gas exit from the sampling chamber and spread radially outward from the center with continued cooling of that surface. The monitor shall accurately measure the sample dew point temperature between 0 and minus 70°F while operating at an ambient temperature of 70 ± 5°F. Means shall be provided for the operator to manually freeze the temperature display at any point during the cool-down cycle. The monitor shall also incorporate a means to ensure that precipitation does not become deposited on the outside windows, window nut, or sampling chamber during operation.

3.3.3 CSM, automatic detection option. Air cooled automatic CSM monitors shall consist of either the components required for the LP (see 3.3.1) or the HP monitor (see 3.3.2) and additional components so that the monitor shall automatically recognize the initial formation of frost/dew on the precipitating surface. Operation of the air sampling and cooling systems hardware shall be manual and in accordance with the operational requirements of 3.3.1 or 3.3.2. As an option, these monitors may be constructed to automatically cool the mirror surface using thermoelectric devices. In either case recognition of the frost/dew point shall be accomplished automatically, without need for visual inspection by the operator. When frost/dew initially forms on the precipitating surface (mirror), the temperature shall be defined as the frost/dew-point. Automatic detection of precipitation on the mirror surface shall be accomplished by photoelectrically sensing the change in reflectance. This change in reflectance of the mirrors shall be detected by

monitoring the intensity of light reflected from the area of the mirror surface where frost/dew first forms. An electronic interlock shall be provided between the precipitation detector and the dew point temperature indicator. The precipitation detector shall automatically freeze the displayed dew point temperature. Upon detection of mirror precipitation, a separate indication lamp or light emitting diode shall also be provided to signal that precipitation has been detected. The detection system shall be provided with optic balance adjustments to compensate for mirror surface reflectance and illumination source degradation. Meter movements or other visual indicators shall be provided to indicate proper adjustment of the optic balance controls for actual mirror reflectance and illumination source conditions. The automatic detection option shall be tested and operation verified.

3.3.3.1 Operational requirements. When all residual moisture has been cleared from the mirror surface, the monitor shall reset itself and shall operate repetitively. The response time of the precipitation detector shall be rapid enough to provide measured dew-point accuracy when cooled at the fastest rate specified in 3.10.3.1 or 3.10.3.2. If the automatic feature fails to operate, the monitor shall be constructed so that frost can be visually monitored by changing the viewing assembly or by other means. After the monitor is cleared and dry mirror conditions prevail, the monitor shall be provided with means to adjust the optic balance system between measurements. Adjustment of the optic balance system shall be accomplished through a single rotary knob or pushbutton. Meter movements or other indicators shall provide positive visual indication of proper optic balance adjustment for prevailing mirror and illumination source conditions. These monitors shall also signal when mirror surface or illumination source conditions cannot be compensated and shall require maintenance or replacement. Precipitation detector electronic circuitry shall operate with the required accuracy in ambient temperatures between 41 and 122°F. Electronic and photo-optical components shall store between minus 40 and plus 185°F without damage.

3.3.4 Direct reading hygrometers. Direct reading hygrometers shall be as specified in 3.3.4.1 and 3.3.4.2.

3.3.4.1 Monitor component requirements. The DRH unit shall be provided in a single portable case, containing all of the components required for operation. Removal of the case cover shall provide access to a single panel containing all operator controls, external connections (air and electrical), and indicators. The DRH unit shall consist of, but need not be limited to, the following components:

(a) HP or LP air sampling hardware
(b) Sample air tubing and connectors.
(c) Sample cell with electronic sensor.
(d) Sensor connecting cable and connectors.
(e) Dew point temperature indicator and electronics.
(f) Sample pressure sensor or gauge.
(g) Electrical power cable and connectors.
(h) Filter.

3.3.4.2 Operational requirements. The hygrometer shall be operated by connecting the sampling system inlet tubing to a HP or LP sample gas source, and connecting the power cable to a 115 volt alternating current (Vac), single-phase, 60 Hz electrical outlet. The sampling system shall provide means for clearing moisture from the sample cell, tubing, and piping before each measurement is taken. Measurements shall be performed by exposing the electronic sensor to sample air at full line pressure, within the sample cell. The sensor unit shall develop an electrical signal dependent on the incident vapor pressure of the sample air. The electronic indicating system shall automatically convert this electronic signal to an equivalent dew point temperature in °F and display this value on a digital readout. The sensor shall be constructed so that it may be replaced by another internally calibrated sensor (of the same construction), without need for extensive monitor recalibration. The hygrometer unit shall accurately measure sample dew point temperatures between plus 50 to minus 70°F while operating at an ambient temperature of 70 ± 5°F. The displayed dew point temperature shall correspond to the actual sample air dew point, at pressure, within the sample cell. Indication of the actual sample pressure in lb/in^2 shall also be provided.

3.4 Construction. Monitors shall be constructed as specified in 3.4.1 through 3.4.4.9.

3.4.1 CSM, low pressure. Low pressure CSMs shall be as specified in 3.4.1.1 through 3.4.1.9.

3.4.1.1 Heat exchangers. Heat exchangers shall be of a counter flow air-to-air construction and shall be constructed of copper tubing with transverse fins for optimum heat transfer and minimum exposure to fouling. Heat exchangers shall be constructed to work at a maximum pressure of 150 lb/in^2 for a temperature range from minus 100 to plus 100°F. Pressure drop from the inlet connection through the heat exchanger tubing to the vortex tube shall not exceed 2 lb/in^2. Shell side shall withstand a working pressure of 5 lb/in^2 in the temperature range of minus 100 to plus 100°F.

3.4.1.2 Vortex tube. Vortex tube cooler shall utilize not more than 6 standard cubic feet per minute (ft^3/min) plus or minus 10 percent of air at 80 lb/in^2 and shall deliver 40 percent of its effluent at atmospheric pressure.

3.4.1.3 Sampling chambers. The mirror in sampling chamber of the LP monitor shall be illuminated so that the precipitation (frost or dew) visually contrasts with the mirror surface. The sampling chamber shall withstand a maximum internal working pressure of 150 lb/in^2 for temperatures ranging from minus 100 to plus 100°F. Chambers shall have an inlet sample connection, an outlet sample connection, a means for installing (and removing) the precipitating surface, and an integral viewing window of at least 1/2-inch diameter and light transmission capability to allow easy viewing of the entire precipitating surface. Internal volume of the chambers shall be of minimum size consistent with the constructed performance parameters. The distance between the viewing window and the precipitating surface shall be sufficient to prevent window frosting and inhibit heat transfer. Chambers shall have a pressure relief valve, rupture disc, or other part that will relieve before a window fails or blows out.

3.4.1.4 Sample flowmeter and control valve. A variable area type of flowmeter with an integral flow regulating valve, Brooks Instrument Division Model 20 or 2700-V, or equal, located in the flowmeter inlet shall be provided. The sample system shall establish and maintain the sample gas flow rate at any selected value in the range of 1 to 10 standard cubic feet per hour (ft^3/hr) by adjusting the manual control valve. If the normal panel operating position does not position the flowmeter to accurately measure the flow rate, instructions for use of the flowmeter shall be prominently displayed on the monitor panel.

3.4.1.5 Windows. Windows shall be cut from plate so that the viewing surfaces are not machined. After machining and polishing, windows shall be stress relieved as recommended by the contractor for the thickness and type or grade of plastic used. Repolishing shall be permissible after stress relieving. Windows shall not optically distort at any working pressure up to the maximum. Windows shall withstand a working pressure of 150 lb/in^2 in the chamber with temperature range from minus 150 to plus 150°F. Aperture shall be a minimum of 1/2 inch in diameter and light transmission shall be at least 92 percent.

3.4.1.6 Precipitating surface (mirror). Precipitating surface (mirror) shall be ground flat, plated if required, and then polished to a mirror finish. Mirror thickness shall be sufficient to withstand the chamber working pressure with a ratio of four to one safety factor. Precipitating surface shall be insulated from conductive heat transfer through supporting structures. Working pressure shall be 150 lb/in^2 maximum. Mirror shall be constructed and cooled so that precipitation shall initially form at the center of the mirror and spread radially outward with a decreasing mirror temperature. The mirror shall be coldest at the center.

3.4.1.7 Optical viewing assembly. An optical viewing assembly shall be furnished to enhance visual recognition of the initial formation of precipitation on the mirror. Increasing the contrast between the mirror and frost/dew upon it shall be considered an acceptable method.

3.4.1.8 Valves. Flow diverting valves shall be low-torque, ball-type. Flow throttling valves shall be needle types. The valves shall withstand a working pressure of 150 lb/in^2 at temperatures ranging from 0 to 100°F. Valve material may be brass or corrosion-resisting steel. Flow diverting valves shall have less than 1 lb/in^2 pressure drop under normal conditions.

3.4.1.9 Tubing. Tubing, including the exhaust tubing, shall be metallic and of a maximum outside diameter of 1/4 inch. Tubing shall withstand a working pressure of 150 lb/in^2 at temperatures from minus 50 to plus 150°F. Allowable pressure drop shall be as specified in 3.4.1.1.

3.4.2 CSM, high pressure. High pressure CSMs shall be as specified in 3.4.2.1 through 3.4.2.8.

3.4.2.1 Heat exchanger. Heat exchanger shall be of the counter flow air-to-air construction. Tubing shall be coiled finned type, wrapped on a mandrel and operated at a maximum working pressure of 5000 lb/in^2. Flow through the cooling device shall not exceed 1.5 ft^3/min at 3000 lb/in^2. The shell shall withstand a working pressure of 25 lb/in^2.

3.4.2.2 Sampling chambers. The mirror in sampling chamber of the HP monitor shall be illuminated so that the precipitation (frost or dew) visually contrasts with the mirror surface. The sampling chamber shall withstand a maximum internal working pressure of 5000 lb/in^2 with temperature ranging from minus 150 to plus 150°F. The chamber shall have an inlet connection, a window for viewing the mirror, means for cleaning the mirror, and an outlet connection to the blowdown valve. Internal volume in the chamber shall be minimum consistent with design performance parameters. The distance between the viewing window and the mirror surface shall be sufficient to prevent heat transfer and fogging. The chamber shall have a pressure relief valve or rupture disc that will relieve before the window fails.

3.4.2.3 Sample flowmeter and control valve. A variable area type of flowmeter with an integral flow regulating valve, Brooks Instrument Division Model 20 or 2700-V, or equal located in the flowmeter inlet shall be provided. The sample system shall establish and maintain the sample gas flow rate at any selected value in the range of 1 to 10 ft^3/hr by adjusting the manual control valve. Instructions for use of the flowmeter shall be prominently displayed on the monitor panel if the normal panel operating position does not position the flowmeter to accurately measure the flow rate.

3.4.2.4 Windows. Windows shall be cut from plate so that the viewing surfaces are not machined. After machining and polishing, windows shall be stress relieved as recommended by the contractor for the thickness and type or grade of plastic used. Repolishing is permissible after stress relieving. Windows shall not optically distort at any working pressure up to the maximum. Windows shall withstand a maximum working pressure of 5000 lb/in^2 in the chamber with temperatures ranging from minus 150 to plus 150°F. Aperture shall be minimum of 1/2-inch in diameter and light transmission shall be at least 92 percent.

3.4.2.5 Precipitating surface (mirror). Precipitating surface (mirror) shall be ground flat, plated if required, and then polished to a mirror finish. Mirror thickness shall be sufficient to withstand the chamber working pressure with a ratio of four to one safety factor. Precipitating surface shall be insulated from conductive heat transfer through supporting structures. Body of the precipitating surface shall withstand a differential pressure of 5000 lb/in^2. There shall be an orifice penetrating through its center and the precipitating surface shall be of such depth as to permit Joule-Thompson cooling of the expanded gas sample and consequent heat extraction from the mirror. Outer mirror surface from a radius of 3/16 to 1/4 inch from mirror center shall be backed by insulation to prevent precipitation on this portion of the annular mirror surface. Frost shall initially form adjacent to the orifice and shall spread radially outward as the mirror is further cooled.

3.4.2.6 Optical viewing assembly. An optical viewing assembly shall be furnished to enhance recognition of the initial formation of precipitation on the mirror. Increasing the contrast between the mirror and frost/dew upon it shall be considered an acceptable method.

3.4.2.7 Valves. Flow diverting and throttling valves shall be suitable for the intended service. Valves shall withstand a working pressure of 5000 lb/in^2 at temperatures of plus or minus 150°F. Blowdown valves shall be low torque, nominal 1/8-inch plug valves installed with their packing on the downstream side of the valve seat.

3.4.2.8 Tubing. Tubing shall be corrosion-resistant steel, of a maximum outside diameter of 1/4 inch and constructed for a working pressure of 5000 lb/in^2. The tubing shall be sized so that maximum pressure drop from supply to sampling chamber shall not exceed 60 lb/in^2 when the supply pressure is 3000 lb/in^2.

3.4.3 CSM, automatic detection. Construction of components for CSM monitors equipped with automatic indication devices shall be in accordance with applicable requirements (see 3.4.1 or 3.4.2), in addition to the requirements specified herein.

3.4.3.1 Retrofit precipitation detector. Where precipitation detectors are installed as a retrofit to manual chilled surface devices, the optoelectronic assembly shall be provided in a single modular enclosure. This module shall be constructed for direct mounting to the existing sample chamber window or viewing optics. Attachment of the module to the monitor shall be accomplished through the use of screws or other simple fasteners to simplify removal for inspection and replacement. Pressure seal and strength of the sample chamber shall not be degraded when the detector is properly installed.

3.4.3.2 Optical viewing assembly. An optical viewing assembly shall be provided for direct visual observation of precipitation formation. The assembly shall be constructed in accordance with 3.4.1.7 or 3.4.2.6. In the event of automatic detector failure, the viewing assembly shall be constructed so that it may be used in place of the precipitation detector to allow visual operation. As an option, the optical viewing assembly may be provided as a separate attachment. Provisions shall be made to allow for expedient installation of this assembly when visual operation is required.

3.4.4 Direct reading hygrometer. Direct reading hygrometers shall be as specified in 3.4.4.1 through 3.4.4.9.

3.4.4.1 Sensor element. The base of the sensing element shall consist of an aluminum structure, rigidly formed and mounted to minimize fatigue damage caused by incident vibration. The surface of this structure shall be treated to create a porous, hygroscopic layer of aluminum oxide on it. An extremely thin layer of porous noble metal shall be deposited upon the treated structure and electrodes attached to form an electrically capacitive sensing device. The electrical capacitance present between the electrodes of the sensing element shall be a repeatable function of the incident sample air vapor pressure. The surface area of the sensing element shall be made as large as possible to minimize the effects of incident contaminants. The above constraints of construction shall be followed to ensure long-term stability of the sensor. When materials other than aluminum oxide are to be used for the sensor to detect water vapor content, prior NAVSEA approval is required.

3.4.4.2 Sensor housing and fittings. The sensor element and any supporting electronic devices shall be mounted with a rugged, probe-type of housing to ensure pressure-tight insertion into the hygrometer sample cell. Electrical connections to the sensor cable shall be made through a quick disconnect receptacle at the base of the housing. The base of the sensor housing shall be made of stainless steel and provided with a threaded extension to mate with the sample cell insertion port. Tapered pipe threads shall not be used. Pressure seals shall be provided as needed to prevent leakage of sample air when the probe is inserted into the sample cell. When the probe is properly installed, the moisture sensing element shall project beyond the threaded extension of the base so that it shall be fully exposed to sample air. A porous cylindrical shield shall be provided to surround the sensing element in order to protect it from mechanical damage. Local electronic devices or modules required to support the sensor operation shall be securely mounted within the sensor base structure. These devices shall be properly sealed or encapsulated, where required, for complete environmental protection.

3.4.4.3 Monitor unit and enclosure. The dew point monitor and supporting electronics shall be provided in a separate, removable enclosure mounted within the hygrometer case. Removable covers shall be provided to allow complete access to internal components for inspection and servicing. With the exception of interconnecting wiring and conductors, electronic circuitry shall be incorporated into self-contained, modular units. Each module shall consist of circuit boards, hard-wired devices, and discrete plug-in components, integrated into a rugged mechanical package. Major system functions shall be divided among individual circuit modules in order to expedite maintenance and troubleshooting. The exposed face of the monitor unit shall contain all controls and indicators required for normal hygrometer operation (see 3.6.2).

3.4.4.4 Air sampling system. In order to accurately measure the sample air dew-point at line pressure, the air sampling system shall be constructed so that the sampling tube (see 3.7) shall be connected directly to the air line output connections (see 3.7.2). The system shall consist of an air sampling chamber, piping, valves, indicators, and other pneumatic hardware required for applying sample air to the dew-point sensor probe (see 3.4.4.2). Sensors or gauges shall be provided to continuously monitor the sample air pressure.

3.4.4.5 Sample chamber. The flow of air into the sample chamber shall be set to maintain a fixed volume of sample air for measurement by the hygrometer's dew-point sensor. The chamber shall be provided with full threaded inlet ports for pressure-tight insertion of the dew-point probe housing. The sample chamber and associated sampling hardware shall be constructed to maintain full, rated line pressure during each measurement. Instrument ports or connections shall be provided to allow continuous monitoring of the internal chamber pressure by gauges or transducers. Valving hardware shall be provided to allow minute air flow through the chamber, as required, to obtain optimum sensor performance. The valving system shall be constructed to ensure the required flow of sample air does not significantly lower the chamber pressure below line value. The chamber shall be provided with a pressure relief device to prevent rupturing or explosion at pressure exceeding its designed values.

The operation of the pressure relief device shall be verified and tested for repeatability. Rupture or blow-out of the pressure relief device shall not occur below the maximum rated pressure valve of the hygrometer unit. The sample chamber shall be mounted so that the dew-point sensor probe may be inserted and replaced without need for disassembly of the hygrometer unit.

3.4.4.6 Purging system. The sampling system shall be provided with means to allow periodic purging of residual moisture from inside the sampling hardware, through use of blowdown valves or other permanently mounted pneumatic control devices. The purging system shall clear sufficient amounts of moisture to prevent alteration of the sample air dew-point during the measurement procedure.

3.4.4.7 Valves and hardware. Construction of sample system valves shall be in accordance with 3.4.1.8 or 3.4.2.7, as applicable. Electric heater elements shall be integrated into the valve assemblies, as required, to prevent freezing during normal operation. The heater elements shall operate on 115 Vac, 60 Hz power, and be controlled from the hygrometer main power selector switch (see 3.6.2.4). Tubing, piping, and end fittings shall be constructed in accordance with 3.7 and 3.8, as applicable.

3.4.4.8 Pressure monitor. Instrumentation shall be provided for continuous monitoring of the sample air pressure value in lb/in^2. Pressure gauges provided for this application shall be items qualified under MIL-G-18997. Where electrical pressure transducers are used, measured pressure values shall be selectively displayed on the dew-point monitor (see 3.6.2).

3.4.4.9 Electrical cables and connectors. A single multiconductor cable shall be provided for all connections between the sensor receptacle and indicator unit enclosure. Shielding shall be provided to minimize electromagnetic interference coupling.

3.5 Electronic circuits and components. Electronic circuits and components shall be as specified in 3.5.1 through 3.5.11.

3.5.1 General requirements. Electrical parts, mechanical parts, processes and material shall be selected and applied in accordance with the applicable requirements specified in MIL-E-16400, except as specified herein.

3.5.2 Electron tubes. Electron tubes and vibrators shall not be used.

3.5.3 Batteries. Batteries shall not be used.

3.5.4 Fuses. Fuses shall be in accordance with MIL-F-15160. Fuses shall be selected so that the overload blowing characteristics and short circuit interrupting capacity specified in MIL-F-15160 matches the overload protection requirements of the equipment and wiring being protected and the short circuit capacity of the supply circuit. Fuse ferrules for normal blowing (characteristic A) fuses and for time lag (characteristic B) fuses in ratings of 30 amperes and above shall be silver plated. High interrupting capacity (characteristic C) fuses shall be silver plated. Glass tube fuses shall not be used.

3.5.4.1 Fuse mounting. Fuses shall be mounted in panel mounted, indicating type fuseholders in accordance with MIL-F-19207. Fuseholders FHL10U in accordance with MIL-F-19207/1 or FHL11U in accordance with MIL-F-19207/2 are preferred types.

3.5.4.2 Fuse and fuseholder installation requirements. Fuse and fuseholder installation requirements shall be as follows:

(a) Use of two fuses in parallel in lieu of one larger fuse shall be prohibited.
(b) Fuses shall be located so they will not be influenced by excessive equipment heat flow or be near a high operating temperature part.
(c) Fuseholders shall be mounted for access from the front face of the equipment.
(d) Fuseholders shall be installed so that the test probe hole is located in the downward direction.
(e) Fuseholders shall not be installed for use as disconnects for line circuits.
(f) Information plates shall be provided adjacent to the fuseholders for each set of fuses and shall indicate the fuse type designation and the circuit (for example, F09A250V8AS, 115 Vac). In addition, "SPARE" shall be marked adjacent to each spare fuseholder. The letters shall be at least 3/64-inch high.

3.5.5 Printed circuit boards. Wherever practical, electronic systems and modules shall be constructed on circuit cards. Printed circuit card fabrication shall be in accordance with applicable sections of MIL-STD-275 and MIL-STD-454.

3.5.6 Switches. Switches shall be selected so that rated currents and voltages (make, break, carry) are not exceeded in the intended application, as well as for their ability to withstand the shipboard environments. Selected switches shall conform to one of the following specifications.

Switch type	Specification	Application
Rotary, snap action	MIL-S-15291	Power circuits 10A, 30A, 60A, and 200A
Rotary, snap action, enclosed	MIL-S-15743	Power circuits 10A, 30A, 60A, and 200A
Rotary, circuit selector (low current capacity)	MIL-S-3786	Low current circuits (2 amperes or less)
Sensitive, limit, pushbutton (snap action)	MIL-S-8805	Power and control circuits up to 40A
Toggle (snap action)	MIL-S-3950	Power and control circuits up to 20A

Switch type	Specification	Application
Lighted pushbutton (snap action)	MIL-S-22885	Power and control circuits up to 10A
Printed circuit and wheel (detent action)	MIL-S-22710	Circuit selection low current
Reed switches (snap action)	MIL-S-55433	Control circuit low currents

Where moisture seals are required for switches, boots in accordance with MIL-B-5423 shall be used.

3.5.7 Integrated circuits (microcircuits). Wherever practical, integrated circuit modules shall be utilized to minimize the number of discrete components composing each system. Integrated circuit devices shall conform to applicable sections of MIL-M-38510.

3.5.8 Illumination bulbs. Illumination source components shall be incandescent or gas discharge types. In all cases, the illumination devices shall have a rated life of 5,000 hours or greater at its rated operating voltage. Rated life shall be based upon the period for which the lamp shall produce sufficient lumen output for normal operation of the indicator, accounting for normal depreciation factors.

3.5.9 Temperature sensors. Sensors used for measurement of chilled surface temperature may be platinum resistance element or approved semiconductor integrated circuit devices. Two sensors that shall sense temperatures between minus 150 to plus 150°F, to an accuracy of plus or minus 1°F, and with a maximum response time of 200 milliseconds shall be provided, built within the mirror (see 3.4.4.2). Sensors shall be mounted with the active elements adjacent to the cooled side of the precipitating surface of the mirror, to sense the precipitation surface temperature to within 1°F. When thermocouples are used and electrical junctions such as splices, switches, terminals, and other parts occur in the wiring, they shall be of the same metal alloy as the thermocouple wire in order to avoid errors.

3.5.10 Pressure transducers. Electromechanical pressure transducers used for monitoring sample pressure shall have a rated accuracy of plus or minus 1 percent. Transducers shall be 2 or 4 wire types, and in all cases connection to the signal conditioner shall be made through a single, shielded cable. Transducers meeting applicable requirements as specified in MIL-P-24212 shall be used.

3.5.11 Display elements. Shock and vibration resistant 1/2-inch segmented light emitting diodes or liquid crystal elements shall be used for construction of monitor readout displays. Elements shall be rated for 200,000 hours typical life. Shock and vibration resistance shall be demonstrated by testing in accordance with the applicable requirements of 4.6.

3.6 Readouts and controls. Readouts and controls shall be as specified in 3.6.1 through 3.6.2.4.

3.6.1 Temperature/pressure readout (CSM). CSM temperature/pressure readout shall be as specified in 3.6.1.1 and 3.6.1.2.

3.6.1.1 Digital temperature indicator. Digital temperature indicator shall provide four illuminated digits for readout of minus 150 to plus 150°F permanently installed on monitor panel front. Temperature display shall have resolution of 0.1°F. Integrated solid-state circuits shall be used where practical. Indicator shall provide the following features:

(a) Repeatability - Plus or minus 0.3 percent.
(b) Calibration - Ice point and full scale.
(c) Ambient temperature range - Operating 41 to 122°F.
(d) Automatic cold junction - Stability of plus or minus 1 microvolt per °F change around midpoint between 32 and 122°F (if thermocouple is used).
(e) Response time - 1 second to within 0.5 percent of final reading.
(f) Sample rate - 2 per second.
(g) Display - Three and one-half digits (numerical one plus three full digits 0 to 9) and sign. Construction in accordance with 3.5.11.
(h) Display hold button - Provide manual freezing of the displayed temperature when activated, with reset for normal operation.
(i) Polarity - Bipolar, automatic plus and minus indication.
(j) Relative humidity - 0 to 95 percent (noncondensing).
(k) Thermocouple - Copper constant (type T) (if thermocouple is used).
(l) Power requirements - 115 volt, 60 Hz, power dissipation 4.0 watts nominal, single-phase.
(m) Sensor burnout - Blanking of the three least significant digits, flashing digit, or any other recognizable indication.

3.6.1.2 Indicator switch. A selector switch shall be installed on the front panel of the monitor. The switch shall perform the following functions for operation of the temperature indicating system:

(a) Select either mirror temperature sensor.
(b) Select one of the three external temperature inputs.
(c) Select the output of the pressure transducer for display.

3.6.2 Dew-point readout and controls (DRH). Controls and indicators for the measurement of sample air dew-point shall be installed on the exposed face of the monitor unit enclosure. These devices shall be mounted in close proximity to each other and arranged in an orderly manner to facilitate hygrometer operation. Nameplates shall be provided for each component in accordance with MIL-E-16400 and this specification. The following control and indication devices shall be provided, in accordance with the requirements of each corresponding sub-paragraph.

(a) Dew-point readout (see 3.6.2.1); pressure option (see 3.6.2.2).
(b) Calibration controls (optional, see 3.6.2.3).
(c) Monitor power switch (see 3.6.2.4).

3.6.2.1 Dew-point readout (DRH). An electronic digital readout shall be provided for the indication of measured dew-point temperature. The readout shall display the measured sample air pressure. When dew-point temperature is measured, four digits of the readout shall be used to indicate the numerical value, with a fifth providing indication of the sign (plus or minus). Displayed dew-point temperature shall be in °F with a resolution of 0.1 degree. Construction of the readout and its components shall be in accordance with the requirements of 3.5.11.

3.6.2.2 Pressure indication. Where electromechanical transducers are used to monitor sample pressure, indication shall be provided through the dew-point display. When sample pressure is measured, four digits of the readout shall be used to indicate numerical value. Readout configuration shall integrate both modes of operation so that displayed values shall easily be read in either mode. Displayed dew-point temperature shall be °F with a resolution of 0.1°F. Displayed sample pressure shall be in lb/in^2 with a resolution of 1 lb/in^2. Construction of the readout and its components shall be in accordance with the requirements of 3.6.2. Two indicator lights or light emitting diodes shall be provided for positive indication of the readout mode. One indicator shall be illuminated only when the readout is displaying dew-point and the other shall be illuminated when pressure is being displayed. A single two-position switch shall be provided to select display of dew-point or pressure values through the hygrometer readout.

3.6.2.3 Calibration controls. Calibration of the hygrometer for replacement sensor probes, if necessary, shall be accomplished by controls and procedures described herein. Only one calibration device and a single mode selector switch shall be required (as a maximum) for complete system calibration, following probe replacement as described in 3.4.4.2. Calibration shall be accomplished by placing the mode selector switch (if required) in the CALIBRATE position. The operator shall then be provided with means to calibrate the system using only the single calibration device and the dew-point readout. When in the calibration mode, the hygrometer shall provide positive indication of proper system calibration for the new probe, through the dew-point readout or other indicators. The calibration mode switch shall be a two-position, snap action device, constructed in accordance with 3.5.6. The calibration device shall be manually operable, without need for any tools or external equipment. As an option, calibration may be accomplished by the insertion of a semiconductor memory module that has been matched to the replacement probe. In cases where this option is provided, matching identification numbers or codes shall be clearly engraved on both the probe and its corresponding memory module. In addition, provisions shall be made to allow insertion of the memory module without extensive indicator disassembly or removal of internal parts.

3.6.2.4 Monitor power switch. A single two-position switch shall be provided for control of 115 Vac power into the hygrometer unit. This switch shall be a two-position snap action device, constructed in accordance with 3.5.6.

3.7 Sampling tube assembly, sample tube fittings, and adaptors. Each monitor or sample cell shall be furnished with a sampling tube assembly with end fittings constructed to connect the tube to the gas sample source at one

end and the monitor at the other end. Loose components shall be secured in a compartment in the cover of the monitor behind a hinged panel. Inlet fittings of the monitor and the end fittings of the sampling tube shall be provided with tethered caps to prevent loss. Sampling tube shall be 6 feet long overall. Material used for the sampling tube, fittings, and adaptors shall be type 304 or 316 corrosion-resisting steel (Unified nos. S 30400 and S 31600). O-rings shall be in accordance with MIL-R-83248, type I.

3.7.1 Flexible tubing (sampling tube). Flexible tubing shall be as follows:

Low pressure. Tubing shall be 1/4-inch corrugated metal hose with an internal polytetrafluoroethylene (PTFE) sleeve and a braided cover. Tubing shall be constructed for 150 lb/in^2 working pressure, and shall be stamped or tagged with the working pressure.

High pressure. Sampling tube shall be made from PTFE lined braided metal hose or 1/8-inch capillary tubing with spiral interlocked armor applied over the capillary. If capillary tube, the end connections shall be attached in a manner to prevent tension from being applied to the tube. Tubing shall be constructed for 5000 lb/in^2 working pressure. The sampling tube shall be stamped or tagged with the working pressure.

3.7.2 End fittings and adaptors. End fittings and adaptors shall be as follows:

Low pressure. Sample tube shall be furnished with a 1/4-inch plain male nipple constructed to mate with a Snap-tite, Inc. E-series quick-disconnect coupling, part number SVEAC4-4-15 (316) or equal, at one end and a tailpiece with a 9/16-inch union nut at the monitor end. Inlet fittings of the monitor shall use 9/16-inch straight thread O-ring face seal connectors constructed for 150 lb/in^2 working pressure. A 1/4-inch plain female coupler with a 1/4-inch female NPT end fitting, Snap-tite, Inc. part number SPEAC4-4F (316) or equal, shall be furnished to adapt to other test connections. Adaptor shall be clipped to a support inside the cover storage compartment.

High pressure. Sample tube shall have at both ends tailpieces and 9/16-inch union nuts constructed to fit 9/16-inch straight thread O-ring face seal connectors on the monitor. Fittings shall be constructed for 5000 lb/in^2 working pressure. Union nuts shall be free to turn on their tailpieces without exerting twist on the tubing. An adaptor to 37-degree flared tube shall be provided. Adaptor shall be tethered to the sampling tube.

3.8 Piping. Piping shall be in accordance with 3.8.1 through 3.8.5.

3.8.1 Brazing. Brazing shall be in accordance with NAVSEA 0900-LP-001-7000.

3.8.2 Welding. Welding shall be in accordance with MIL-STD-278.

3.8.3 Threads. Threads shall be in accordance with FED-STD-H28.

3.8.4 Fastening devices. Screws, pins, bolts, and similar parts shall be installed with means for preventing loss of tightness. When subject to removal or adjustment, these parts shall not be swaged, peened, staked, or otherwise permanently deformed.

3.8.5 Cleaning and surface finishes. Surfaces of castings, forgings, molded parts, stampings, and welded parts shall be cleaned and free from sand, dirt fins, sprues, scale, flux, and other harmful or extraneous materials. External surfaces shall be smooth and edges shall be either rounded or beveled.

3.9 Portable case. Hygrometer components, tubing, and wiring shall be provided in a single, portable case. The case shall be rugged, lightweight, compact, and furnished with a carrying handle. Maximum size of the case shall not exceed 14 inches wide by 12 inches deep by 14 inches high. With all of the hygrometer components installed, the maximum weight of the case shall not exceed 30 pounds. The case shall be provided with a removable cover containing storage facilities for loose cables, hoses, and connectors. The cover shall be sealed and gasketed to prevent entry of dirt and moisture. Removal of this cover shall provide complete access to the hygrometer operating panel. This panel shall contain all control and indication devices associated with the air sampling and dew-point measurement systems. These devices shall be mounted within a single plane and grouped together according to their functions. Connection ports to external air or electrical lines shall be mounted on the panel. The panel shall include a 120 volt power cable with standard plug for operation from a standard electrical receptacle. No ports or openings shall be located on the outside of the case, with the cover in place. Other hygrometer components shall be rigidly mounted within the base of the hygrometer case, below the operating panel. Provisions shall be made for access to major components, for inspection and maintenance. This access shall be accomplished through removal of screws, bolts, pressure seals, or other conventional fasteners. Identification nameplates for panel mounted components shall be provided in accordance with MIL-E-16400 and this specification. The external surface of the case shall have a label prominently marked "Frost-Point/Dew-Point Monitor," with the applicable pressure and dew-point ranges in lb/in^2 and °F. Where pressure relief devices are mounted within the case, they shall be oriented in a direction which ensures venting occurs away from the operator.

3.9.1 Semi-permanent mountings. The external surface of the case shall be equipped with provisions for shock and vibration resistant semi-permanent mounting to shipboard bulkheads or machinery. These provisions shall allow for normal operation of the hygrometer when proper mounting has been completed.

3.10 Performance. Performance shall be as specified in 3.10.1 through 3.10.10.

3.10.1 System accuracy. System accuracy shall be as specified in 4.6.1.

3.10.2 Accuracy, temperature monitor (CSM units). Accuracy of the temperature monitor shall be as specified in 4.6.2.

3.10.2.1 Accuracy of temperature measurement. Accuracy of temperature measurement shall be as specified in 4.6.2.1.

3.10.2.2 Calibration drift. The temperature monitor shall not exhibit a calibration drift characteristic in excess of plus or minus 1°F per year, as extrapolated from the results of testing procedures specified in 4.6.2.2.

3.10.2.3 Zero drift. The temperature monitor shall not exhibit a calibration drift characteristic in excess of 10 microvolts per year, as extrapolated from the results of testing procedures specified in 4.6.2.3.

3.10.3 Cooling rate. Cooling rates shall be as specified in 3.10.3.1 and 3.10.3.2.

3.10.3.1 Low pressure. Starting with the mirror at ambient temperature and using 80 lb/in^2 air, the LP monitor shall reach a mirror temperature of minus 50 ± 2°F within 5 minutes and then perform three additional mirror cool-down cycles from minus 20 to minus 50°F within an additional 5 minutes. Tests to determine conformance to these requirements shall be performed in sequence. The total time to attain the specified temperature for the four cool-down cycles shall not exceed 10 minutes.

3.10.3.2 High pressure. Starting with the mirror at ambient temperature and using 3000 lb/in^2 air, the HP monitor shall reach a mirror temperature of minus 60 ± 2°F within 5 minutes.

3.10.4 Pressure. Pressure shall be as specified in 3.10.4.1 and 3.10.4.2.

3.10.4.1 High pressure monitors. When tested in accordance with 4.6.4, the monitor pneumatic components shall withstand the maximum pressure applied to the sample inlet without rupture or failure. Pressure relief devices shall relieve before the applied air pressure exceeds 5500 lb/in^2 gauge. However, relief or blow-out shall not occur below 5000 lb/in^2 gauge.

3.10.4.2 Low pressure monitors. When tested in accordance with 4.6.4, the monitor pneumatic components shall withstand the maximum pressure applied to the sample inlet without rupture or failure. Pressure relief devices shall relieve before the applied pressure exceeds 200 lb/in^2 gauge. Pressure relief or blow-out shall not occur below 165 lb/in^2 gauge.

3.10.5 Window cyclic and strength. Windows shall not crack, craze, or shown signs of distortion during and after testing as specified in 4.6.5.

3.10.6 Vibration. The equipment shall meet the basis of acceptability defined in MIL-STD-167-1 for type I environmental vibration requirements. Repetitive variation or blanking of the displayed dew-point temperature shall be considered a major failure. Other equipment failures shall be evaluated on the basis of corrective action required to restore accurate dew-point measurements. Failures which require disassembly of the equipment or replacement of its major components shall be considered major failures. Accuracy of dew-point measurements following the vibration tests shall be in accordance with 3.10.1.

3.10.7 Shock. The equipment shall conform to the basis of acceptability described in MIL-S-901. When shock tested in accordance with 4.6.7 the monitor shall not be accepted if it ejects or scatters internal parts outside of the equipment case. Following completion of the shock tests, the unit shall retain full operational capability, without need for repairs requiring disassembly or replacement of parts. System accuracy following the shock test shall be in accordance with 4.6.2.1.

3.10.8 Power supply compatibility. The hygrometer system electrical power supply shall be compatible with type I power input as defined in DOD-STD-1399, section 300. Nominal power input voltage and frequency shall be 115 volt, 60 Hz, single-phase. Power line transients and spikes with magnitudes, duration, repetition rates and decay characteristics as specified in DOD-STD-1399, section 300 shall not cause equipment damage or degrade equipment performance. The maximum difference in indicator reading at any voltage and frequency condition, plus or minus 10 percent of nominal (115 volt, 60 Hz), with the same air sample input, shall not exceed 0.5 percent of full-scale.

3.10.9 Electromagnetic susceptibility and emission. The equipment shall demonstrate conformance to the following requirements of MIL-STD-461, part 5 or 6 as applicable, when tested in accordance with 4.6.10. Requirements CE01, CE03, CS01, CS02, CS09, RE01, RE02, RS01, RS02, and RS03 shall apply.

3.10.10 Magnetic silencing. The equipment shall demonstrate conformance to the relative magnetic permeability requirements of DOD-STD-2143 when tested in accordance with 4.6.11.

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.

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

(a) Qualification inspection (see 4.3).
(b) Quality conformance inspection (see 4.4).

4.3 Qualification inspection. Qualification inspection shall be conducted at a laboratory satisfactory to NAVSEA. Qualification inspection shall consist of the examinations and tests specified in table III and shall be performed in the sequence listed.

4.3.1 Samples for qualification. Sample monitors of the operating pressure range for which qualification is desired shall be submitted for the qualification inspection specified in table III.

TABLE III. Qualification testing.

Examination and tests	Applicable equipment	Requirement	Test
Examinations	All	---------	4.5
System accuracy	All	3.10.1	4.6.1
Accuracy of temperature measurement	CSM	3.10.2.1	4.6.2.1
Zero drift	CSM	3.10.2.3	4.6.2.3
Calibration drift	CSM	3.10.2.2	4.6.2.2
Cooling rate	CSM	3.10.3, 3.4.1.2, 3.4.2.1	4.6.3
Magnetic silencing	All	3.10.10	4.6.11
Pressure strength	All	3.10.4	4.6.4
Window cyclic and strength	CSM	3.10.5	4.6.5
Vibration	All	3.10.6	4.6.6
Shock	All	3.10.7	4.6.7
Power supply compatibility	All	3.10.8	4.6.8
Power supply spike	All	3.10.8	4.6.8.1
Sensor interchangeability	DRH	3.10.1	4.6.9
Electromagnetic interference	All	3.10.9	4.6.10

4.4 Sampling for quality conformance inspection. Sampling shall be as specified in 4.4.1 through 4.4.3.

4.4.1 Lot (parts and subassemblies). For purposes of inspection, a lot shall consist of all parts and subassemblies offered for delivery at one time.

4.4.2 Lot (assembled monitors). For purposes of inspection, a lot shall consist of all monitors offered for delivery at one time.

4.4.3 Sampling for examination of parts and subassemblies. A random sample of parts and subassemblies shall be selected from each lot (see 4.4.1) in accordance with MIL-STD-105 for the examination specified in 4.5.1. The acceptable quality level (AQL) shall be 1.0, inspection level I.

4.4.4 Quality conformance inspection. Each monitor offered for delivery shall be subjected to the examinations and tests listed in table IV. Failure of any equipment to meet the requirements of this specification shall be cause for rejection.

TABLE IV. Quality conformance testing.

Examination and tests	Applicable equipment	Requirement	Test
Examinations	All	---	4.5
System accuracy	All	3.10.1	4.6.1
Accuracy of temperature	CSM	3.10.2.1	4.6.2.1
Cooling rate	CSM	3.10.3, 3.4.1.2, 3.4.2.1	4.6.3
Pressure strength	All	3.10.4	4.6.4
Window cyclic and strength	CSM	3.10.5	4.6.5
Power supply compatibility	All	3.10.6	4.6.6
Power supply spike	All	3.10.8	4.6.8.1

4.5 Examination. Examinations shall be performed in accordance with 4.5.1 and 4.5.2.

4.5.1 Parts and subassemblies. Each sample part and subassembly selected in accordance with 4.4.3 shall be examined for unauthorized material, dimensions, evidence of defective parts or workmanship, construction, surface finish, and optical distortion in windows. Any unit containing one or more defects shall be rejected and if the number of defective units in any sample exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

4.5.2 Assembled monitors. Each monitor shall be examined for dimensions, surface finish, workmanship, assembly, construction, identification plates, and stowage of loose parts. Defective monitors shall be cause for rejection.

4.6 Testing. Tests shall be performed in accordance with 4.6.1 through 4.6.11.

4.6.1 System accuracy. System accuracy shall be tested as specified in 4.6.1.1 through 4.6.1.4.

4.6.1.1 System accuracy (qualification). The hygrometer system accuracy shall be tested by repeated measurements of the output air from a standard generator (see 4.6.1.3) made in parallel with a standard chilled surface instrument (see 4.6.1.4). Measurements for testing of LP style hygrometers shall be made at standard air dew-points of minus 40, minus 20, and 0°F at 120 ± 5 lb/in^2. Measurements for testing of HP styles shall be made at dew-points of minus 60, minus 20, and 0°F at 4600 ± 100 lb/in^2. For each standard air dew-point, five dew-point readings shall be taken on the instrument under test, using normal operating procedures for that instrument. Simultaneously, sample air dew-point measurements shall also be made using the standard instrument, which shall be connected to a parallel sample port on the generator output. For testing of HP style hygrometers, a pressure reducing parallel connection to the standard instrument may be used. Provisions shall be made to ensure that the actual moisture content of the sample air is not significantly altered by passing through these connections. The dew-point value as determined by measurement of the air generator internal parameters (see 4.6.1.3) shall also be calculated and recorded. Following testing at each standard air dew-point, instrument error values shall be determined by taking the algebraic difference between the individual readings obtained on the sample instrument and the instrument under test. The set of error values determined for each tested dew-point shall meet the requirements of 4.6.2.1. When the results of five initial measurements at a particular standard dew-point fail to meet the requirements specified in 4.6.2.1, the test may be repeated to obtain additional error values, up to a maximum of five additional measurements. New error values thus generated shall be integrated with previously obtained values in determining compliance.

4.6.1.2 System accuracy (quality conformance). The hygrometer system accuracy shall be tested using equipment and procedures specified in 4.6.1.1, 4.6.1.3, and 4.6.1.4. However, only three measurements shall be taken at each standard air dew-point. The error values shall be taken as the algebraic difference between the standard instrument and the instrument under test.

4.6.1.3 Standard air generator. Accuracy of dew-point hygrometers shall be verified by measuring the output of a dynamic standard air generator that shall produce sample air with stable, predetermined dew-point values, near the maximum rated pressure of the instrument. The standard air produced by the generator shall maintain a stable dew-point value at each tested operating point, within plus or minus 5°F of the desired value, for the duration of each test. The standard generator shall incorporate features to allow precise calculation of the standard air dew-point by direct measurement of internal temperature, pressure, and flow parameters. Sample output ports shall be

provided for parallel connection of multiple dew-point monitoring instruments, as required to accomplish the procedures described in 4.6.1.1 and 4.6.1.2. Provisions shall be made to ensure that the moisture content of sample air is not significantly altered when passing through any of these connections.

4.6.1.4 Standard hygrometer instrument. The standard instrument shall be a precision chilled surface device, utilizing automatic precipitation detection. The precipitation surface shall be cooled thermoelectrically using thermal and optic feedback systems to assure precise control of the precipitation formation. The system shall also incorporate features for automatic detection and compensation of changes in internal optical conditions. The rated accuracy shall be better than plus or minus 0.5°F of actual dew-point and temperature sensor calibration shall be National Bureau of Standards (NBS) traceable.

4.6.2 Accuracy of temperature monitor (CSM units). Accuracy shall be tested in accordance with 4.6.2.1 through 4.6.2.3.

4.6.2.1 Accuracy of temperature measurement. Accuracy of CSM temperature monitors shall be verified by repeated measurements of the simulated temperature signal output from an electronic calibration instrument. Calibration of the simulated temperature shall be NBS traceable with a rated accuracy of better than 0.25°F, in the range between 0 and minus 60°F, and an overall accuracy better than 0.25 percent of span between plus 150 and minus 150°F. Five test measurements shall be taken at simulated temperature values of 20, 0, minus 20 and minus 40°F. The error values for each simulated temperature shall be determined as the algebraic difference between the known value set on the calibration instrument, and that indicated on the instrument under test. These calculated uncertainties in temperature measurement shall not exceed plus or minus 1 percent of the full span value for the temperature range between plus 150 to minus 150°F. In addition, calculated uncertainties derived from the above tests in the temperature range between minus 100 and 0°F shall not exceed plus or minus 1°F. The calculated uncertainty shall be derived for each operating point from this test data and the following mathematical formula:

$$U = \frac{1}{N} \sum_{i=1}^{N} E_i$$

Where:

U = Calculated uncertainty.
E = The value of measured indication error from testing runs at each operating point as stated above.
N = Number of tests run at each operating point.

4.6.2.2 Calibration drift test. Calibration drift of the temperature monitor shall be tested by operating it continuously for a period of not less than 1 month. Conformance to the requirement specified in 3.10.2.2 shall be determined by comparison of temperature indications from a temperature monitor of known characteristics.

4.6.2.3 Zero drift test. Zero drift of the temperature monitor shall be tested by operating it continuously for a period of not less than 1 month. Conformance to the requirement specified in 3.10.2.3 shall be determined by comparison of temperature indications from a temperature monitor of known characteristics. Zero drift test may be conducted concurrently with the calibration drift test specified in 4.6.2.2.

4.6.3 Cooling rate test. Monitor shall be connected to an air pressure of 80 lb/in^2 at 70°F (LP) or 3000 lb/in^2 at 70°F (HP) and shall not exceed the cooling rate requirements of 3.10.3. Flow rates for air cooled monitors shall be observed and recorded to verify conformance to 3.4.1.2 or 3.4.2.1, as applicable.

4.6.4 Pressure strength. The monitor pneumatic sample inlet tube shall be connected to an external dry air compressor that shall generate pressures in excess of the monitor's maximum rated pressure. The applied pressure shall be monitored by instrumentation with an accuracy of better than plus or minus 5 percent of actual value. Pressure shall be steadily increased until operation of the pressure relief devices occurs. The pressure reached when relief occurs shall be noted and recorded. Performance shall be in accordance with 3.10.4.

4.6.5 Window cyclic and strength tests. At least 10 and not less than 1 percent of the windows from each lot of monitors and each lot of window material shall be subjected to cyclic and strength tests. Cyclic load test shall consist of 1000 cycles from 0 to 225 lb/in^2 (LP) and 0 to 7500 lb/in^2 (HP) with strength tests at 500 and 1000 cycles. During the cyclic load tests, the maximum pressure specified shall be held for a minimum of 30 seconds. Strength test shall consist of hydrostatically pressurizing the windows to 225 lb/in^2 (LP) and 7500 lb/in^2 (HP) for a minimum of 1 hour. Failure of any window during this test shall require that at least 20 percent of the remaining windows from the lot be tested. Failure of any one of these samples shall be cause for lot rejection. Samples subjected to the window test shall be retained for inspection and shall not be used in deliverable monitors.

4.6.6 Vibration. The equipment shall be energized by connecting the power cable to a 115 volt, 60 Hz, single-phase grounded receptacle and ready for operation. A simulated electronic dew-point signal shall be applied to the sensor input of the monitor and adjusted to provide a mid-range dew-point value on the display. The equipment shall then be tested in accordance with MIL-STD-167-1 for type I environmental vibrations. During the test, monitors and controls shall be observed for a change in status. After the vibration test, the equipment shall be subjected to the following examinations and tests:

(a) Examination for evidence of mechanical damage or loosening of parts.
(b) System accuracy - see 4.6.1.1.

4.6.7 Shock. The monitor unit and case shall be considered a principal unit and subjected to the HI shock tests specified in MIL-S-901 for grade A, class II, type A equipment. Application of the shock hammer directly against

the operator's panel (see 3.9) shall not be required. The monitor cover may be removed prior to the shock testing procedure. Following completion of the test procedure, the equipment shall undergo the following examination and tests: During the shock test, the unit is not operating and is not connected to electrical power or an air supply.

(a) Examination for evidence of mechanical damage or loosening and ejection of parts.
(b) System accuracy - see 4.6.1.2.

4.6.8 Power supply compatibility. The monitor shall be energized with alternating current power at a nominal value of 115 Vac, 60 Hz. The sample air input shall be connected to the output of the standard air generator described in 4.6.1.3. A standard hygrometer instrument as described in 4.6.1.4 shall be connected in parallel with the instrument under test to monitor actual dew-point of the sample air. The generator shall be adjusted to provide sample air having a dew-point temperature near the mid-range value of the instrument under test. The supply voltage and frequency shall then be adjusted to the upper and lower limit of permissible variation for the instrument power supply as specified in 3.10.8. The system shall be operated at each limit for at least 15 minutes, and measurements of sample air dew-point shall be taken and recorded. The change in indicated dew-point on the tested instrument (not resulting from changes in actual sample dew-point) shall be in accordance with 3.10.8.

4.6.8.1 Power supply spike voltage. Following the line voltage variation tests conducted in accordance with 4.6.8, the equipment power input shall be subjected to a test voltage spike of 2500 volt positive peak amplitude. The waveshape of the spike voltage shall be as described in DOD-STD-1399, section 300 for type I power systems. The spike shall be impressed directly onto 115 Vac power supplied to the instrument. Performance under test shall be in accordance with 3.10.8.

4.6.9 Sensor interchangeability (DRH qualification). The accuracy test of 4.6.1.1 shall be repeated for all DRH units following replacement of the original sensor probe (see 3.4.4.2) with a second pre-calibrated probe of the same construction. Monitor calibration procedures may be performed in accordance with 3.6.2.3, but no additional adjustments or part interchanges shall be made. Performance demonstrated by the hygrometer using the replacement probe shall be in accordance with 3.10 and 3.10.1.

4.6.10 Electromagnetic interference. Conformance to the requirements of 3.10.9 shall be demonstrated by performing electromagnetic interference tests in accordance with the applicable methods of MIL-STD-462 or the NAVSEA approved electromagnetic interference test plan.

4.6.11 Magnetic permeability. Conformance to the requirements of 3.10.10 shall be demonstrated by performing relative magnetic permeability tests in accordance with the applicable methods of DOD-STD-2142.

4.7 Inspection of packaging. Sample 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.

[illegible] magnetic [illegible] when the indicator is subjected to the magnetic

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 6.4.)

5.1 Packing requirements. Frost-point/dew point, semi-portable compressed air monitors 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).

(a) Navy fire-retardant requirements.

(1) Treated lumber and plywood. Unless otherwise specified (see 6.2), 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), 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.

6. NOTES

6.1 Intended use. Monitors are intended to support maintenance of Navy shipboard compressed air dehydrators.

6.2 Ordering data. Acquisition documents should specify the following:

(a) Title, number, and date of this specification.
(b) Whether DRH or CSM type units are required (see 1.2.1).
(c) Whether low pressure or high pressure is required (see 1.2.2).
(d) Whether optional automatic indicator is required (see 3.3.3).
(e) Level of preservation, packing, and marking required (see 5.1).
(f) When fire-retardant materials are not required (see 5.1(a)).

6.3 Qualification. With respect to products requiring qualification, awards will be made only for products which are, at the time set for opening of bids, qualified for inclusion in Qualified Products List QPL-24144 whether or not such products have actually been so listed by that date. The attention of the contractors is called to these requirements, and manufacturers are urged to arrange to have the products that they propose to offer to the Federal

Government tested for qualification in order that they may be eligible to be awarded contracts or purchase orders for the products covered by this specification. The activity responsible for the Qualified Products List is the Naval Sea Systems Command, SEA 55Z3, Department of the Navy, Washington, DC 20362-5101 and information pertaining to qualification of products may be obtained from that activity. Application for qualification tests shall be made in accordance with "Provisions Governing Qualification SD-6" (see 6.3.1).

6.3.1 Copies of "Provisions Governing Qualification SD-6" may be obtained upon application to Commanding Officer, Naval Publications and Forms Center, 5801 Tabor Avenue, Philadelphia, PA 19120.

6.4 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.

6.5 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.

6.6 Subject term (key word) listing.

Chilled surface
Flowmeter
Hygrometer
Mirror temperature control valve
Precipitation detector
Retrofit precipitation

6.7 Changes from previous issue. Asterisks are not used in this revision to identify changes with respect to the previous issue due to the extensiveness of the changes.

Preparing activity:
Navy - SH
(Project 6685-N794)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE
MIL-M-24144D(SH)	MONITORS, FROST-POINT/DEW-POINT, COMPRESSED AIR, SEMI-PORTABLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)* _____
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wording:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)

DD FORM 82 MAR 1426

PREVIOUS EDITION IS OBSOLETE.