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An American National Standard

Standard Specification for Temperature Monitoring Equipment[1]

This standard is issued under the fixed designation F2362; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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

1. Scope

1.1 This specification covers the requirements for equipment intended to provide control input and monitoring of temperatures in general applications. Equipment described in this specification includes temperature indicators, signal conditioners and power supplies, and temperature sensors such as thermocouples and resistance temperature element assemblies.

1.2 Special requirements for Naval shipboard applications are included in the Supplementary Requirements section.

1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3951 Practice for Commercial Packaging

E344 Terminology Relating to Thermometry and Hydrometry

3. Terminology

3.1 *Definitions*—Definitions of terminology shall be in accordance with Terminology E344.

4. Classification

4.1 *General*—Temperature measuring devices are generally classified as either temperature sensors or thermometers. Thermometers are not covered by this specification. Temperature sensors are classified by design and construction. Sensors may also be classified by the manner of response, basically mechanical or electrical, to a change in temperature. Mechanical response is characterized by some mechanical action as temperature changes. Electrical response is characterized by the production or change of an electrical signal or property as temperature changes. The following describes the most common types of sensors:

4.2 *Thermocouples*—Thermocouples are constructed in a variety of designs to provide measurement of direct or differential temperature. Thermocouples are commonly installed using a thermowell which protects the thermocouple but also delays the rapid response time characteristic of thermocouples.

4.2.1 *Principle of Operation*—Most thermocouples utilize two wires fabricated from dissimilar metals joined at one end to form a measuring junction that is exposed to the process medium being measured. The other ends of the wires are usually terminated at a measuring instrument which forms a reference junction. When the two junctions are exposed to different temperatures, electrical current will flow through the circuit (Seebeck Effect). The measurement of millivoltage resulting from the current is proportional to the temperature being sensed.

4.2.2 *Types of Thermocouples*—Thermocouples can be divided into functional classes by materials and therefore, temperature ranges. The three classes are base metal, noble metal, and refractory metal. Although many types are commonly used in industrial applications, the Instrument Society of America (ISA) has assigned letter designations to seven types. By convention, the practice of using a slash mark to separate the materials of each thermocouple wire is widely accepted. Likewise, the order in which the materials appear also denotes polarity of the wires; positive/negative when the measuring junction is at a higher temperature than the reference junction. The following are examples of typical thermocouples:

[1] This specification is under the jurisdiction of ASTM Committee F25 on Ships and Marine Technology and is the direct responsibility of Subcommittee F25.10 on Electrical.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Class	Type	Materials	Temperature (max)
Base metal	J	Iron/constantan	1000°C (1832°F)
Base metal	T	Copper/constantan	1000°C (1832°F)
Base metal	K	Chromel/Alumel	1000°C (1832°F)
Base metal	E	Chromel/constantan	1000°C (1832°F)
Base metal	---	Alloys of copper, nickel, iron, chromium, manganese, aluminum, and other metals	1000°C (1832°F)
Noble metal	---	Various noble metals	2000°C (3632°F)
Refractory metal	---	Tungsten-rhenium, tantalum, molybdenum, and their alloys	2600°C (4712°F)

4.3 *Resistance Temperature Measuring Devices*—Resistance thermometers measure changes in temperature based on changes in resistance of the sensor element exposed to the temperature. Two common types are resistance temperature detectors which have metal sensor elements and thermistors which have semiconductor sensor elements.

4.3.1 *Resistance Temperature Detectors (RTDs)*—An RTD consists of sensor which uses a metal wire or fiber which responds to changes in temperature by changing its resistance. The sensor is connected to a readout via a bridge circuit or other means of translating the resistance to a temperature value.

4.3.1.1 *Types of RTDs*—RTD designs include averaging RTDs, annular RTDs, and combination RTD-thermocouples. Averaging RTDs are characterized by a long resistance element. Annular RTDs have sensors that are designed to provide a tight fit within the inner walls of thermowells. Combination RTD-thermocouples have both an RTD and a thermocouple housed in the same sheath.

4.3.2 *Thermistors*—Thermistors are made of solid semiconductor materials, usually complex metal oxides, that have a high coefficient of resistance. Thermistors are available with positive and negative temperature coefficients of resistance and are usually designated PTC and NTC thermistors, respectively. The temperature range for typical thermistors is 100 to 300°C (212 to 572°F).

4.3.2.1 *Types of Thermistors*—Thermistors are classed by the configuration of the semiconductor material. Common types are the bead, disc, washer, and rod thermistors. Leads are attached to semiconductor materials, except where metal plated faces are used for contact to complete the circuit.

5. Ordering Information

5.1 The purchaser should provide the manufacturer with all of the pertinent application data outlined in the acquisition requirements.

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

5.2.1 Title, number and date of this specification,
5.2.2 Classification required,
5.2.3 Quantity of units required,
5.2.4 Type of enclosure mounting,
5.2.5 Power requirements,
5.2.6 Equipment temperature ranges,
5.2.7 Size or weight limitations,
5.2.8 Disposition of qualification test samples,
5.2.9 Product marking requirements, and
5.2.10 Special preservation, packaging, packing and marking requirements.

6. Materials and Manufacture

6.1 *Temperature Sensors*—The materials for all wetted parts shall be selected for long term compatibility with the process medium.

7. Physical Properties

7.1 *Description*—The equipment specified herein in conjunction with the thermocouples or resistance temperature measuring elements comprise a temperature instrument. The temperature monitoring equipment may consist of the following units and may be built integrally together and housed in the same enclosure:

7.1.1 *Signal Conditioner*—The signal conditioner shall convert the sensing element output to a continuous linear analog signal directly proportional to temperature.

7.1.2 *Power Supply*—The power supply shall provide excitation energy to the signal conditioner and sensor.

7.1.3 *Test Device*—A test device shall be furnished to provide a calibrated test signal used for calibrating the equipment.

7.2 *Size and Weight Considerations*—A dimensional outline of the temperature monitoring equipment showing overall and principle dimensions in sufficient detail to establish space requirements in all directions necessary for installation and servicing will greatly assist proper selection. In many applications weight is a critical limitation.

7.3 *General Features*—Requirements for general features shall be specified. General features consist of the following:

7.3.1 Output,
7.3.2 Equipment range,
7.3.3 Adjustments,
7.3.4 Failsafe output,
7.3.5 Isolation,
7.3.6 Enclosure,
7.3.7 Power supply requirements, and
7.3.8 Cable entrance and connection.

8. Performance Requirements

8.1 *Service Life*—The purchaser may have a minimum specified service life requirement. Critical service life requirements shall be specified in the acquisition requirements.

8.2 *Performance Considerations*—Certain performance characteristics may be deemed critical to the intended or desired function of temperature monitoring equipment. Performance tolerances are usually expressed in percent of equipment span. The following performance characteristics and environmental exposures should be tailored to each purchaser's intended application:

8.2.1 Accuracy,
8.2.2 Repeatability,
8.2.3 Threshold and deadband,
8.2.4 Ripple,
8.2.5 Warm-up time,
8.2.6 Input resistance,

8.2.7 Supply voltage or frequency, or both,
8.2.8 Temperature error,
8.2.9 Response time,
8.2.10 Temperature,
8.2.11 Insulation resistance,
8.2.12 Vibration, and
8.2.13 Shock.

9. Workmanship, Finish, and Appearance

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

10. Number of Tests and Retests

10.1 *Test Specimen*—The number of test specimens to be subjected to qualification testing shall depend on the sensor design. If each range is covered by a separate and distinct design, a test specimen for each range may require testing. In instances where a singular design series may cover multiple ranges and types, only three test specimens may need to be tested provided the electrical and mechanical similarities are approved by the purchaser. In no case, however, should less than three units, one unit each representing low, medium, and high ranges, be tested, regardless of design similarity.

11. Test Data

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

12. Inspection

12.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:
12.1.1 Qualification testing, and
12.1.2 Quality conformance testing.

12.2 *Qualification Testing*—Qualification test requirements shall be specified where applicable. Qualification test methods should be identified for each design and performance characteristic specified. Test report documentation requirements should also be specified.

12.3 *Quality Conformance Testing*—Quality conformance testing is accomplished when qualification testing was satisfied by a previous acquisition or product has demonstrated reliability in similar applications. Quality conformance testing is usually less intensive than qualification, often verifying that samples of a production lot meet a few critical performance requirements.

13. Certification

13.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test results shall be furnished.

14. Product Marking

14.1 Purchaser specified product marking shall be listed in the acquisition requirements.

15. Packaging and Package Marking

15.1 *Packaging of Product for Delivery*—Product should be packaged for shipment in accordance with Practice D3951.

15.2 Any special preservation, packaging, or package marking requirements for shipment or storage shall be identified in the acquisition requirements.

16. Quality Assurance Provisions

16.1 *Warranty:*
16.1.1 *Responsibility for Warranty*—Unless otherwise specified, the manufacturer is responsible for the following:
16.1.1.1 All materials used to produce a unit, and
16.1.1.2 Manufacturer will warrant his product to be free from defect of workmanship to produce the unit.

17. Keywords

17.1 resistance temperature detector (RTD); thermistor; thermocouple

SUPPLEMENTARY REQUIREMENTS

TEMPERATURE MONITORING EQUIPMENT (NAVAL SHIPBOARD USE)

The following supplementary requirements established for U.S. Naval shipboard application shall apply when specified in the contract or purchase order. When there is conflict between the standard (ASTM F2362) and this supplement, the requirements of this supplement shall take precedence for equipment acquired by this supplement. This document supercedes MIL-T-15377, Temperature Monitor Equipment, Naval Shipboard, for new ship construction.

S1. Scope

S1.1 This supplement covers temperature monitoring equipment which continuously monitors and selectively indicates, at a central location, a number of temperatures at remote equipment locations on board naval ships.

S1.2 *Monitoring Equipment*—Monitoring equipment, in conjunction with the temperature sensor assemblies and interconnecting cabling, comprise a temperature measuring and alarm system. In order to warn operating personnel of abnormal temperature conditions, the system shall energize an audible and visual alarm when the temperature at a particular location is below or above a preset limit. Monitoring of temperatures shall be accomplished by measuring the electromotive force (emf) output of thermocouples or by measuring the signal output due to changes in resistance of temperature sensing elements. Temperature monitoring equipment shall actuate external audible alarms specified herein.

S1.3 *Selective Temperature Readout Equipment*—Selective temperature readout equipment, in conjunction with temperature sensor assemblies and interconnecting cabling, comprise a temperature measuring system. In order to enable operating personnel to measure a number of temperatures at remote points, the system shall enable the operator to manually select the desired point to be measured, convert the selected temperature sensor output to a signal proportional to temperature, and display this signal on a meter calibrated in temperature °C (°F). Readout of temperatures shall be accomplished by measuring the output of thermocouples or by measuring the signal output due to changes in resistance of temperature sensing elements.

S1.4 The U.S. Government preferred system of measurement is the metric SI system. However, since this item was originally designed using inch-pound units of measurement, in the event of conflict between the metric and inch-pound units, the inch-pound units shall take precedence.

S2. Referenced Documents

S2.1 *Commercial Documents:*

ANSI C96.1 Temperature Measurement Thermocouples[3]

S2.2 *Government Documents:*[4]

S2.2.1 *Military Standards:*

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

MIL-STD-1399 Interface Standard for Shipboard Systems Electric Section 300 Power, Alternating Current (Metric)

S2.2.2 *Military Specifications:*[4]

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

MIL-PRF-19207/1 Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL10U

MIL-PRF-19207/2 Fuseholders, Extractor Post Type, Blown Fuse Indicating, Type FHL11U

S3. Terminology

S3.1 *Definitions:*

S3.1.1 *temperature monitoring equipment*—the necessary equipment required to continuously or selectively sense and indicate various temperatures including audible and visual alarms when specified.

S4. Classification

S4.1 *Classification*—Monitoring and selective temperature readout equipment classification shall be of following format:

Example: ASTM F2362S1-IC/A-1-RTE-40

Specification	Type	Alarm	Sensing Technique	Number of Channels
F2362S1	IC/A	1	RTE	40
	(see S4.2)	(see S4.3)	(see S4.4)	(see S4.5)

S4.2 *Type*—The equipment shall be designated by the 3 letter symbols as follows:

IC/A—Continuous, simultaneous monitoring of remote temperature sensors for alarm and also manual selective temperature readout.

IC/I—Manual selective temperature readout for measuring temperatures at several remote locations.

IC/S—Continuous, sequential scanning of remote temperature sensors for indication and alarm.

S4.3 *Alarm*—The alarm technique shall be designated by a single number as follows:

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[4] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

1—Alarm on temperature above the set level or (exclusive or) below the set level as operator selected.

2—No alarm provision—temperature readout only.

S4.4 *Temperature Sensing Technique*—The temperature sensing technique shall be designated by 3 letter symbols as follows:

RTE—Resistance temperature element, platinum.

TCE—Thermocouple temperature element, type K.

S4.4.1 *Readout Ranges*—Readout ranges shall be provided as specified as follows:

(1) For RTE type sensors, the following ranges and meter scales shall be provided:

(a) 5 to 127°C (-40 to 260°F)

(b) 18 to 205°C (0 to 400°F)

(c) 18 to 427°C (0 to 800°F)

(d) 18 to 538°C (0 to 1000°F)

(2) For type TCE sensors, the following ranges and meter scales shall be provided:

(a) 5 to 127°C (-40 to 260°F)

(b) 18 to 205°C (0 to 400°F)

(c) 18 to 427°C (0 to 800°F)

(d) 205 to 816°C (400 to 1500°F)

(e) 260 to 1093°C (500 to 2000°F)

S4.5 *Number of Channels*—The number of channels, corresponding to the number of remote sensors that monitored shall be designated by its numerical value.

S5. Ordering Information

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

S5.2 *Acquisition Requirements*—Acquisition documents should specify the following:

(1) Title, number and date of this specification,

(2) Classification required,

(3) Quantity of items required,

(4) Number of temperature sensors to be monitored,

(5) Setting of alarm channels, if other than 93.3°C (200°F),

(6) Height and weight of equipment assembly,

(7) Number of remote resistance temperature sensors or remote thermocouple temperature sensors monitored by equipment,

(8) Equipment alarm and readout temperature range,

(9) Accuracy or other performance requirements,

(10) Disposition of qualification test samples, and

(11) Unique preservation, packaging and marking requirements.

S6. Materials and Manufacture

S6.1 Unless otherwise specified, equipment shall be fabricated from corrosion resistant materials compatible with system piping materials and process medium.

S7. Physical Properties

S7.1 *Enclosure Assembly:*

S7.1.1 *Temperature Monitor Equipment*—Equipment enclosure assembly shall be of sheet metal, splash-proof construction, and shall be suitable for either panel or bulkhead mounting. Splash-proof construction shall be such that water or solid particles directed at the enclosed equipment or its mounting surface shall have no harmful effect on equipment operation.

S7.1.2 *Continuous Parallel Monitoring (IC/A)*—Enclosure assembly for IC/A monitor equipment shall contain one temperature readout module and the number of alarm modules required to provide the number of alarm channels specified, up to a maximum of 60. Modules shall be readily removable from the enclosure assembly by means of integral plug-in features operable from the front of the enclosure. Access to the interior or back of the enclosure assembly shall not be required to accomplish removal of any module.

S7.1.3 *Temperature Readout Module*—The temperature module shall be a temperature readout device and associated circuits. Necessary controls shall be located on the front panel of the module.

S7.1.4 *Alarm Module (IC/A and IC/I)*—Indicator lights and controls shall be located on the front panel of each alarm module to perform the following functions. Multi-position switches may be utilized to combine control functions specified.

(1) Power on light (white lens).

(2) Alarm light for each temperature monitoring channel (red lens).

(3) External alarm cut-out (silence) switch for each temperature monitoring channel.

(4) Alarm set potentiometer.

(5) External alarm cut-out (silence) switch for temperature monitoring channels (one per equipment).

(6) Alarm circuit reset switch: one per module (if required).

(7) Test switch to verify continuity of alarm circuit, alarm light, and temperature sensor (one per module).

(8) Read (indicate) light on each temperature monitoring channel to light when it has been selected at the readout module.

S7.1.5 *Access (IC/A)*—Electrical connection between alarm and readout modules and between modules and the other circuits within the enclosure assembly shall be by means of quick-disconnect connectors. Required auxiliary circuits, such as the power supply, shall be located within the enclosure assembly in such a location as to be readily accessible from the front of the enclosure assembly. Required controls and indicators, associated with the power supply, shall be on the front panel. Fold down or slide drawer chassis construction may be used. Terminals and terminal boards shall be provided for interconnection to ships power, temperature sensors, and external audible alarm. These terminals shall also be located to be accessible from the front of the enclosure assembly. Three 2.44 m (8 ft) long cable assemblies shall be provided and stowed securely inside each equipment enclosure. With these cable assemblies, it shall be possible to remove any one alarm module and the power supply, readout, alarm, and calibration

modules to operate the equipment in a normal manner on a work bench away from the installed console. These cable assemblies shall only be required to obtain access for special testing, trouble shooting, and repair.

S7.1.6 *Manual Selective Temperature Readout Equipment (IC/I)*—Enclosure assembly shall contain the temperature indicating meter, selector switch for selecting the desired temperature sensor to be read, all required, associated functional circuits and parts, and terminals for interconnection to external power and temperature sensors.

S7.1.7 *Continuous Scanning Monitoring (IC/S)*—Enclosure assembly for IC/S shall contain a readout, a micro processor, input multiplexers, A/D converters, and alarm circuits required to provide the number of channels specified, up to a maximum of 60. Operating controls and the readout shall be accessible from the front panel. A provision shall be included whereby the function of the front panel controls can be disabled to prevent tampering by unauthorized personnel.

S7.1.8 *Temperature Monitor Equipment (IC/A)*—One identification plate shall be provided for each enclosure assembly. Individual identification plates shall be provided on each module (alarm and indicator unit) showing the location of the associated temperature sensing element, next to each alarm light, and identifying the function of controls and indicators located on the front of each module. As an alternate, identification plates showing location of temperature sensor elements may be provided on the overall equipment frame adjacent to each module location. Plates shall also provide for indicating the proper scale to use on the readout for each channel if a dial type meter is used. Adjustment, calibration, setting, and standardization controls located within the enclosure assembly, shall also be identified by means of identification plates. Temperature sensor connection terminals shall be marked to correspond with the position identification for monitor point.

S7.1.9 *Selective Temperature Readout Equipment (IC/I)*—The position of all selector switches shall be marked to identify the temperature sensor selected to be measured. Adjustment, calibration, and sensor connection terminals located within the enclosure assembly shall be identified and marked.

S7.1.10 *Continuous Scanning Monitoring (IC/S)*—The equipment display shall identify the location of the temperature element when an alarm condition occurs.

S7.2 *System Requirements:*

S7.2.1 *Temperature Monitor Equipment (IC/A)*—IC/A temperature monitor equipment shall provide for continuous paralleled monitoring of up to 60 temperature sensors. Equipment shall be modular, with individual modules having plug-in features as specified in S7.1.2. There shall be at least 3 types of modules:

(1) Monitor and alarm,

(2) Readout, and

(3) Power supply module.

Each monitor and alarm module shall monitor 4 temperature sensors. Equipment shall be capable of operating, as specified herein, with each of the 60 temperature alarm set points adjusted for a different temperature setting. Any alarm may be activated regardless of the state of any other alarm. For purposes of standardization, the factory setting shall be approximately 93.3°C (200°F) for points, unless otherwise specified in the acquisition requirements.

S7.2.2 *Visual Alarm*—Each monitor point shall be uniquely associated with a specific remote temperature sensor and shall have its own individual indicating light. When the temperature at the point being monitored reaches a predetermined temperature setting (alarm point), the indicator light shall be energized and remain energized until manually reset.

S7.2.3 *Audible Alarm*—One relay or electronic switch having 5 A minimum rating DPDT operation shall be provided for supplying 115 V alternating current (ac) power for actuating an external audible alarm simultaneously with activating the visual alarm. The alarm relay switch shall be wired to the panel terminal boards in the cable entrance stuffing box. The audible alarm shall be activated when any one or more of the temperatures being monitored reaches the predetermined (alarm) setting. Each channel shall provide a manual switch for cutting out the audible alarm for its own monitoring point. This cut-out shall not prevent any of the other channels from sounding the audible alarm should the temperature at any other monitored point reach the predetermined (alarm) setting. A single, master cut-out switch with associated indicator light shall be provided, which will disable the sounding of the external audible alarm for the entire system.

S7.2.4 *Independent Action*—The monitoring and alarm action of individual points shall be independent of each other. Action of indicating an alarm condition at one or more monitor points shall not prevent the system (equipment) from indicating an alarm condition at other monitor points.

S7.2.5 *Temperature Readout*—The temperature readout device and channel selector switch shall be provided in a readout module. The selector switch shall be depressed to turn so that momentary contact is not made with intermediate channels. The continuous, automatic monitor and alarm capability of the system shall not be affected by the selection of a temperature sensor for reading. When a channel temperature reading is being taken, the alarm feature of all points including the one being measured shall be maintained. The operation of the readout module shall not depend on balancing motors, slidewires, potentiometers, or similar devices. The use of potentiometers shall be limited to test, adjustment, and calibration purposes only.

S7.2.6 *Test Feature*—A test switch shall be provided for each monitor and alarm module for testing alarm lights and continuity of each temperature sensor and alarm circuits of that module. When the switch is operated to the "test" position, the channel alarm light shall indicate an alarm condition. Failure of the channel alarm light on the module to light shall indicate an open circuit in the lamp, temperature sensor, or in the associated alarm circuit. This test operation shall not change the normal state of the alarm relays or external relays.

S7.2.7 *Fail Safe Design*—The IC/A temperature monitor equipment shall have an inherent "fail safe" feature. An open circuit in the external temperature sensor or its connecting cabling shall result in an alarm condition.

S7.2.8 *Calibration and Setting of Alarm Point*—Design of the IC/A temperature monitor equipment shall be such as to facilitate calibration and adjustment of the individual alarm set

points. Self calibration capability shall be an inherent design feature. Test jacks shall be provided to facilitate direct connection to external instrumentation for test, calibration, and trouble shooting. Calibration, alarm set point adjustment and access to the test jacks shall not require disassembly or changes to the electrical wiring connections.

S7.2.9 *Cold Junction Compensation*—Cold junction compensation for equipment for thermocouple sensing shall be self-contained, automatic, and shall be referenced to 0°C (32°F).

S7.2.10 *Lead Length Compensation*—Equipment for resistance temperature sensing shall provide an input terminal for 3 wire sensor configuration. A means shall be provided to compensate for the resistance of interconnecting wiring between sensor and monitor equipment. This compensating provision and associated sensor input terminal configuration shall be arranged that it can be easily by-passed (removable jumper, alternate terminals, or similar means) for use with 2 wire resistance temperature elements. Equipment for thermocouple sensing shall provide for thermocouple lead length compensation. Accuracy, calibration, and response time shall be independent of thermocouple extension lead length.

S7.2.11 *Size and Weight*—Individual modules (alarm or readout) shall not exceed 15.24 cm (6 in.) in height, 7.62 cm (3 in.) in width, and 30.48 cm (12 in.) in depth. Total weight per module shall not exceed 5.44 kg (12 lb). The equipment assembly, containing the required number of alarm modules, the readout module, and power supply module shall not exceed 50.8 cm (20 in.) in width, and 35.6 cm (14 in.) in depth. The height and weight, determined by the number of temperatures the equipment is designed to monitor, shall be as specified in the acquisition requirements. The equipment assembly, containing the required number of alarm modules to monitor 60 temperatures, shall not exceed 129.6 cm (51 in.) in height. Total weight shall not exceed 90.7 kg (200 lb). For a 40 point monitor system, the equipment assembly shall not exceed 91.44 cm (36 in.) in height, and weight shall not exceed 68 kg (150 lb).

S7.2.12 *Selective Temperature Readout Equipment (IC/I)*—Equipment shall provide for the manual selection of any one of several remotely located temperature sensors and converting the signal output of the selected sensor to the signal required for display on a read-out device, calibrated in °C (°F). The operation of the readout equipment shall not depend on balancing motors, slide-wires, potentiometers, or similar devices. Use of potentiometers shall be limited to test, adjustment, and calibration purposes only. The equipment shall facilitate calibration without disassembly or changes to the electrical wiring connections. Test jacks shall be provided to permit direct connection to test and calibration instruments. An inherent "fail safe" feature shall be incorporated which will result in an off-scale (high or low) reading to signal a failure in the manual selector, associated readout circuits, or an open or short in the external temperature sensor.

S7.2.12.1 *Size and Weight*—Selective temperature readout equipment assembly shall not exceed 30.48 cm (12 in.) in width, 30.48 cm (12 in.) in height, and 35.6 cm (14 in.) in depth. The total weight shall not exceed 18.14 kg (40 lb).

S7.2.13 *Continuous Scanning Monitoring, Indicating, and Alarm Equipment (IC/S)*—IC/S temperature monitor equipment shall provide for continuous scanning via micro processor of up to 60 temperature sensors. Equipment shall be modular, with individual modules having plug-in features. The equipment shall scan at a rate which will allow all channels to be scanned in 5 s or less. Alarm set points and temperature input characteristics shall be able to be re-programmed from the front panel. The equipment shall be capable of annunciating alarms regardless of number (up to 60) and regardless of previous alarm history.

S7.2.14 *Number of Readout Points (IC/A, IC/I and IC/S)*—The number of remote resistance temperature sensors or remote thermocouple temperature sensors monitored by the equipment shall be specified in the acquisition requirements.

S7.3 *Parts Requirements*—Electrical parts, mechanical parts, processes, and material shall be selected and applied to meet the requirements herein.

S7.3.1 *Batteries*—Batteries shall not be used.

S7.3.2 *Electrical Indicating Meters*—Electrical indicating meters shall be high-impact shock resistant, watertight, or hermetically sealed types, in accordance with one of the following:

(1) 11.43 cm (4-½ in.) 250° nominal scale length.

(2) Panel mounted, edgewise type.

S7.3.3 *Digital Readout*—Digital meters utilized in lieu of an electrical indicating meter (analog type readout) shall have a minimum of 4 digits. The meters shall be high-impact shock resistant, and watertight, or hermetically sealed.

S7.3.4 *Fuses*—Fuses shall be selected so that the overload blowing characteristics and short circuit interrupting capacity matches the overload protection requirements of the equipment and wiring being protected and the short circuit capacity of the supply circuit.

S7.3.5 *Fuse Mounting*—Fuses shall be mounted in panel mounted, indicating type fuse-holders. Fuse-holders FHL10 in accordance with MIL-PRF-19207/1 or FHL11 in accordance with MIL-PRF-19207/2 are preferred types.

S7.3.6 *Terminal Boards and Mounting*—Terminal boards shall be stud type and shall be secured only by bolts (machine screws) and shall be capable of ready removal and replacement. They shall be accessible from the front of the enclosure with the front cover plate removed or access door open.

S7.3.7 *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. Rotary switches are preferred for power circuit interruption. Readout channel selector switch shall be a "push to turn" type so that momentary contact is not made with intermediate channels while turning the switch.

S8. Performance Requirements

S8.1 *Calibration and Accuracy*—Temperature monitoring equipment, selective temperature readout equipment, and continuous scanning temperature monitoring equipment shall comply with the calibration and accuracy requirements specified below. Equipment performance requirements specified herein are specified on the basis of simulating the signal output

of the appropriate temperature sensors and applying this signal to the input terminals (temperature sensor terminal points) of the equipment.

S8.1.1 *Accuracy of Alarm Set Point*—Temperature monitoring equipment (IC/A, IC/I, and IC/S) shall permit the setting of the alarm point at any value over the designated temperature span. The error band of the alarm level setting shall be one-half the error band of the temperature readout on any full scale range.

S8.1.2 *Accuracy of Readout*—The readout error of the equipment shall not exceed ±2 % of the readout range for any readout range setting. The temperature indicated on the readout device shall be within ±2 % of the temperature equivalent to the simulated temperature sensor output in ohms or millivolts, as applicable.

S8.2 *Ambient Temperature Error*—The change in temperature reading (temperature error) of the equipment due to any changing ambient temperature from 4.5 to 65°C (40 to 149°F) shall not exceed 0.18 (0.1) % of full scale per °C (°F) change in ambient temperature.

S8.3 *Response Time:*

S8.3.1 *Alarm Circuits (IC/A and IC/I)*—The alarm shall be actuated within 0.1 s when a step signal change of 1.5 % of full scale is applied when the monitoring systems are reading 1.4 % of full scale below the alarm setting for any alarm setting from 5 to 100 % of full scale.

S8.3.2 *Alarm Circuits (IC/S)*—The alarm shall be actuated on the first scan cycle after the alarm condition appears at the input of the equipment. Alarms shall be programmable to actuate either above a set condition or below a set condition.

S8.3.3 *Temperature Readout*—Equipment shall display the steady state temperature reading ±2.0 % in less than 3 s when a step signal equivalent to 80 % (from 10 to 90 %) of full temperature span is applied to the temperature sensor input terminals of the temperature monitoring equipment console.

S8.3.4 *Compensation for RTE*—Equipment shall provide for 3 wire temperature sensor inputs. Means shall be provided to compensate for the resistance of interconnecting wiring between temperature sensor and the indicator equipment. Compensating provision and associated sensor input terminal configuration shall be so arranged that it can be easily bypassed (removable jumper, alternate terminals, or similar means) for use with 2 wire uncompensated resistance temperature sensors.

S8.3.5 *Compensation for TCE*—Cold junction compensation shall be self-contained, automatic, and shall be reference to 0°C (32°F).

S8.4 *Operation:*

S8.4.1 *Temperature Monitor Equipment*—When the equipment is operated under nominal conditions simulating shipboard service (see S11.3), equipment operation shall comply with the following:

(1) Individual visual alarm indicators light when associated test switch is operated (applicable to IC/A and IC/S equipment).

(2) Test, reset, and audible alarm cut out switches operate as required.

(3) Indicator reads required temperature when test and select (or indicate as applicable) switches are operated. Readout accuracy shall be in accordance with S8.1.2.

(4) Alarm indication activated with temperature sensor terminals open or short circuited, except instruments for thermocouple sensors need not detect a short.

S8.4.2 *Selective Temperature Readout Equipment*—When the equipment is operated under nominal conditions simulating shipboard service (see S11.3), equipment operation shall comply with the following:

(1) Accuracy of readout (see S8.1.2).

(2) Selector switch operates in accordance with S8.4.1*(3)*.

(3) Indicator scale is driven to either extreme low or high with temperature sensor terminals open or short circuited.

S8.4.3 *Power Supply Requirements*—Equipment shall operate normally from type I power as defined in MIL-STD-1399, Section 300. Nominal power input voltage and frequency shall be 115 V, 60 Hertz (Hz), single phase. Power line transients and spikes with magnitudes, duration, repetition rates, and decay characteristics as specified in MIL-STD-1399, Section 300 shall not cause equipment damage or affect equipment operation. The maximum difference in indicator reading and alarm setting level at any voltage and frequency condition and nominal (115 V, 60 Hz) with the same input, shall not exceed ½ of 1 % of full scale on all ranges.

S8.5 *Warm-up Time*—Transducer output shall attain a value within ±1 % of the steady-state output with no overshoot in excess of 1 %. Output shall reach this band in 30 min or less and shall remain in this band (see S11.4).

S8.6 *Inclination*—Maximum deviation of indication resulting from inclination shall not exceed 1.0 % (see S11.5).

S8.7 *Enclosure*—There shall be no evidence of water leakage into the equipment enclosure (see S11.6).

S8.8 *Insulation Resistance*—The insulation resistance shall be not less than 10 megohms between power input lines and ground (hull).

S8.9 *Shock*—The temperature monitoring equipment shall show no evidence of mechanical or electrical damage or loosening of parts, when exposed to shock in accordance with MIL-S-901.

S8.9.1 *Temperature Monitor and Readout Equipment (IC/A, IC/I, and IC/S)*—Operating controls shall not change status during shock. There shall be no transfer of switch or relay contacts or change in selector switch position during shock. After shock, without any adjustments, the equipment shall meet the following requirements:

(1) Alarm set point accuracy as specified in S8.1.1 (as applicable).

(2) Indicator accuracy in accordance with S8.1.2.

(3) Operation shall be in accordance with S8.4.

S8.10 *Vibration*—Temperature indicating and monitoring equipment shall operate in accordance with the requirements herein when exposed to type I environmental vibration of MIL-STD-167-1. Equipment range and accuracy requirements shall be demonstrated during and after completion of vibration. Equipment shall show no evidence of mechanical or electrical damage or loosening of parts. Operating controls and relays shall not change status during vibration. There shall be no

momentary or permanent transfer of switch or relay contacts or change in selector switch position during vibration.

S8.11 *Temperature*—Equipment shall operate in accordance with S8.4 when exposed to ambient temperature conditions from 0 to 65°C (32 to 149°F). The equipment shall not be damaged in a non-operating condition when exposed to ambient temperatures of -40 to 70°C (-40 to 158°F).

S9. Workmanship, Finish, and Appearance

S9.1 *Cleaning and Surface Finishes*—Surfaces of castings, forgings, molded parts, stampings, machined and welded parts shall be free of defects such as cracks, porosity, undercuts, voids and gaps as well as sand, dirt, fins, sharp edges, scale, flux, and other harmful or extraneous materials. External surfaces shall be smooth and edges shall be either rounded or beveled. There shall be no burn-through. There shall be no warpage or dimensional change due to heat from welding operation. There shall be no damage to adjacent parts resulting from welding.

S10. Number of Tests and Retests

S10.1 The number of tests and retests, if any, shall be specified in the acquisition requirements.

S11. Test Methods

S11.1 *Calibration and Accuracy*—Monitor and readout equipment calibration and accuracy measurements shall be accomplished by simulating temperature sensor signal output over the designated temperature span. Simulated signal for equipment using the resistance sensing technique shall be resistance values as specified in Appendix B and shall be simulated by a resistance decade (or similar device) having an accuracy of ±0.055 Ω. The simulated signal for equipment using the thermocouple sensing technique shall be millivolts (mV) as specified in ANSI C96.1 and shall be simulated by a stable direct current (dc) voltage source having an accuracy of ±0.025 mV.

S11.1.1 *Accuracy of Alarm Set Point*—Alarm set points shall be calibrated and adjusted in accordance with the instructions contained in the technical manual furnished with the equipment. The accuracy of the alarm set point shall be checked at 5 different temperatures approximately equally spaced over the temperature span for each alarm channel. A signal simulating the temperature sensor output shall then be applied to the equipment input terminals. The accuracy of the alarm set point shall be checked with both increasing and decreasing signals. The signal required to actuate the alarm shall be within the limits specified in S8.1.1.

S11.1.2 *Accuracy of Readout*—The accuracy of the readout portion of equipment types shall be determined at approximately equally spaced intervals over each readout temperature span. The reading, at each simulated temperature input, shall be as specified in S8.1.2.

S11.1.3 *Lead Resistance Compensation*—For equipment which operates with RTE sensors, one of the measurements specified in S11.1.1 and S11.1.2 shall be repeated by inserting a resistance in series with each lead of the resistor simulating the RTE to simulate lead resistance. The resistance in each lead shall be any value between 20 and 30 σ, but the resistance for each lead shall be equal to each other within 0.1 Ω.

S11.2 *Response Time:*

S11.2.1 *Alarm Circuits*—Compliance with S8.3.1 shall be demonstrated by testing at 10, 20, 50, 90, and 100 % of the full alarm setting range.

S11.2.2 *Temperature Readout*—A step input signal, equal to 80 % of the temperature span (from 10 to 90 % of the span) for each temperature range setting shall be applied to the temperature sensor input terminals. Indicator reading shall be as specified in S8.3.3.

S11.3 *Operation (Monitor and Readout Equipment)*—Equipment shall be energized with nominal voltage and frequency (115 V, 60 Hz) and allowed to stabilize for at least 30 min. Input signals, simulating temperature sensor outputs equivalent to approximately mid-range of the temperature span, shall be connected to all equipment input terminals. Equipment controls shall then be actuated in turn to verify compliance with S8.4.1 and S8.4.2. Indicator readings shall be noted and recorded. The supply voltage and frequency shall then be adjusted to the lower limit of permissible variation (see S8.4). Equipment shall be stabilized at this input power for at least 15 min and indicator reading shall be noted and recorded. Supply voltage and frequency shall then be adjusted to the higher limit, stabilized for at least 15 min, and the indicator reading noted and recorded. Temperature sensor inputs during these tests shall remain constant. The change in indicator reading, due to variations in input power shall be within the limits specified in S8.4.

S11.4 *Warm-up Time*—Test shall be conducted to determine the elapsed time between the application or line power to the equipment and the point at which the indication reaches the conditions specified in S8.5.

S11.4.1 The transducer shall be placed in an ambient temperature of 25 ± 2°C (77 ± 3.6°F) for not less than 2 h de-energized. Recording equipment and other auxiliary equipment shall be energized to assure complete warm-up. A simulated signal equal to 80 ± 5 % of indication shall be applied and maintained constant during this test. Performance shall conform to S8.5.

S11.5 *Inclination*—The equipment shall be inclined for a period of at least 1 min in each of the following positions:

(1) 45° forward
(2) 45° backward
(3) 45° to the left
(4) 45° to the right

In each position a reference measurement (see S11.1) shall be made. Performance shall conform to S8.6.

S11.6 *Enclosure*—The enclosure shall be subjected to a solid stream of water from a 2.54 cm (1 in.) nozzle at 246 L (65 gal) per minute at a distance from the equipment of approximately 3.05 m (10 ft). The water stream shall be directed at all surfaces of the enclosed equipment and its mounting surface for a minimum of 5 min. Performance shall conform to S8.7.

S11.7 *Insulation Resistance*—Insulation resistance shall be determined with a test potential of 50 Vdc applied for a minimum of 60 s.

S11.8 *Shock*—Equipment and sensor assemblies shall be tested in accordance with the high-impact shock test specified in MIL-S-901 for grade A, class I, type C equipment.

S11.8.1 *Monitor and Readout Equipment*—The equipment shall be energized during the test with nominal voltage and frequency (115 V, 60 Hz) and sensor input signals shall be 80 % of span. During the test, all operating controls shall be observed for change in status. After the shock test, equipment shall be subjected to the following examinations and tests:

(1) Alarm set point accuracy (see S11.1.1),

(2) Readout accuracy (see S11.1.2),

(3) Operation at nominal voltage and frequency (see S11.3), and

(4) Examination for evidence of mechanical damage or loosening of parts.

S11.9 *Vibration*—Equipment and sensor assemblies shall be tested in accordance with type I vibration of MIL-STD-167-1. Energization, input signals, observations during test and examinations after vibration shall be as specified in S11.8 for the shock test. IC/A system shall have the alarm point set within 4 % of full scale of the incoming temperature level. The temperature level shall be at 90 % of full scale. If an alarm occurs during vibration, any vibration test is a failure and corrective action is required. Frequency variation tests of MIL-STD-167-1 are required with the same settings. It shall be demonstrated that vibration from 1 to 50 Hz in accordance with MIL-STD-167-1 shall not cause alarm.

S11.10 *Temperature:*

S11.10.1 *Operating*—The equipment shall be subjected to the following temperature cycles:

Period (h)	Temperature (±3°C)	Environment
6	0°C (32°F)	Chamber
6	65°C (149°F)	Chamber
6	25°C (77°F)	Stable room or chamber

Cycle periods shall be measured from the time the temperature is stabilized. All tests within a 6-h period shall be continuous. Performance during and after the tests shall conform to S8.11.

S11.10.2 *Non-operating*—The equipment shall be held at each of the two temperature extremes for a period of 24 h. Performance after the test shall conform to S8.11.

S12. Inspection

S12.1 *Classification of Inspections*—The inspection requirements specified herein are classified as follows:

(a) Qualification testing, and

(b) Quality conformance testing.

S12.2 *Qualification*—Qualification tests shall be conducted at a laboratory satisfactory to the purchaser. Qualification tests shall consist of the general examination and the tests specified in Table S1 and shall be conducted on equipment produced with techniques and procedures normally used in production.

TABLE S1 Qualification Testing (Monitor and Selective Temperature Readout Equipment)

Examination and Test	Requirement	Test
General examination	---	S12.5
Calibration and accuracy	S8.1	S11.1
Response time	S8.3	S11.2
Operation (Monitor and Readout Equipment)	S8.4	S11.3

TABLE S1 Qualification Testing (Monitor and Selective Temperature Readout Equipment)

Examination and Test	Requirement	Test
Warm-up time	S8.5	S11.4
Inclination	S8.6	S11.5
Enclosure	S8.7	S11.6
Insulation resistance	S8.8	S11.7
Shock	S8.9	S11.8
Vibration	S8.10	S11.9
Temperature	S8.11	S11.10

S12.2.1 *Qualification Sample—Monitor and Readout Equipment*—One sample of each type and temperature sensing technique with the maximum number of channels for which qualification is sought shall be submitted for examination and test.

S12.2.1.1 *Extent of Qualification*—Qualification of an equipment type will also be extended to equipment of the same design, type, and sensing technique, with lesser number of channels.

S12.2.2 *Test Routine*—Equipment submitted for qualification testing shall be subjected to the tests shown in Table S1 in the order listed. Failure of an equipment to comply with any of the requirements listed shall cause refusal to grant qualification.

S12.2.3 *Disposition of Qualification Samples*—Samples subjected to qualification testing shall be considered consumed and non-deliverable as part of the contract. Final disposition of qualification samples shall be specified in the acquisition requirements.

S12.3 *Quality Conformance Testing*—The sample equipment or sensor assemblies selected shall be subjected to the examinations and tests listed in Table S3. Examinations and tests shall be performed in the order listed.

TABLE S2 Sampling for Quality Conformance Testing

Lot Quantity	Sample Quantity	Nonconformance Quantity
7 and under	All	---
8 to 15	7	1
16 to 40	10	1
41 to 110	15	1
11 to 300	25	2
301 to 500	35	2
501 and over	50	3

TABLE S3 Quality Conformance Testing

Examination and Test	Requirement	Test
General examination	---	S12.5
Calibration and accuracy	S8.1	S11.1
Insulation resistance	S8.8	S11.7
Operation	S8.4	S11.3
Response time	S8.3	S11.2

S12.3.1 *Lot*—Equipment of the same type presented for quality conformance inspection at one time shall be considered a "lot." The lot may include the entire contract quantity, or it may be the production of any convenient time period. Each equipment shall be subjected to general examination and accuracy test.

S12.3.2 *Sampling*—A sample of equipment shall be selected from each lot in accordance with Table S2 and subjected to the examinations and tests specified in Table S3. If the number of nonconforming equipment in any sample exceeds the acceptance number for that sample, the lot represented by the sample shall be rejected.

S12.4 *Test Conditions*—Except for those tests where the following factors are the variables, tests shall be conducted with the equipment operating under the following conditions:

(1) The ambient temperature shall be 25 ± 3°C (77 ± 5.4°F), and the relative humidity shall be between 25 and 50 %.

(2) The supply voltage shall be 115 V nominal.

(3) The supply frequency shall be 60 Hz nominal.

S12.5 *General Examination*—The temperature monitoring equipment shall be given a thorough examination to determine that it conforms to this specification and the approved drawings with respect to material, finish, construction, assembly, dimensions, workmanship, marking, identification, and information plates. This examination shall be limited to those examinations that may be performed without disassembling the unit in such a manner that its performance, durability and appearance would be affected. This examination shall include a mechanical check of all operating controls and adjustments, as applicable.

S13. Certification

S13.1 When specified in the purchase order or contract, the purchaser shall be furnished certification that samples representing each lot have been either tested or inspected as directed in this specification and the requirements have been met. When specified in the purchase order or contract, a report of the test result shall be furnished. It is recommended that all test data remain on file for three years at the manufacturer's facility for review by purchaser upon request.

S14. Product Marking

S14.1 Product marking requirements shall be specified in the acquisition requirements.

S15. Packaging and Package Marking

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

S16. Quality Assurance Provisions

S16.1 *Warranty*—Special warranty requirements shall be specified in the acquisition requirements. Otherwise, the standard commercial warranty applies.

SIGNAL CONDITIONER AND POWER SUPPLY (ELECTRICAL) (NAVAL SHIPBOARD USE)

The following supplementary requirements established for U.S. Naval shipboard application shall apply when specified in the contract or purchase order. When there is conflict between the standard (ASTM F2362) and this supplement's appendix, the requirements of this supplement's appendix shall take precedence for equipment acquired by this supplement's appendix. This document supercedes MIL-T-24387, Temperature Measurement Equipment Signal Conditioner and Power Supply (Electrical) for new ship construction.

S17. Scope

S17.1 This specification covers the requirements for signal conditioners and electrical power supplies used in conjunction with thermocouples and resistance temperature element assemblies for naval ships. It does not include the design of the sensing elements and wells or the requirements for the readout or display.

S17.2 This specification defines equipment intended to provide control input and monitoring of temperatures for shipboard engineering plants.

S17.3 The U.S. Government preferred system of measurement is the metric SI system. However, since this item was originally designed using inch-pound units of measurement, in the event of conflict between the metric and inch-pound units, the inch-pound units shall take precedence.

S18. Referenced Documents

S18.1 *Commercial Documents:*

ANSI/ASQC Q9001-1994 Quality Systems—Model for Quality Assurance in Design, Development, Production, Installation, Inspection, Testing and Servicing[5]

S18.2 *Government Documents:*[6]

S18.2.1 *Military Standard:*

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

S18.2.2 *Military Specifications:*

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

MIL-J-24142 Junction Boxes for Electrical Fittings and Fixtures, General Specification for

MIL-J-24142/3 Junction Box, Submersible, Size 6 by 9

S19. Terminology

S19.1 *Definitions:*

S19.1.1 *thermocouple*, shall be as defined by S34.

S19.1.2 *resistance*, shall be as defined by Section S34.

S19.1.3 *deadband*, the range through which the measurand can be verified without a change in output.

S19.1.4 *static error band*, the maximum deviation from a straight line drawn through the coordinates of the lower span limit at specified output, and the upper span limit at specified output expressed in percent of span.

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036.

[6] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

S20. Classification

Temperature monitoring equipment shall consist of a series of designations which shall be assigned and listed in the format below.

Example: ASTM F2362S17-TRE-4H-YES

Specification	Type	Input Range	Alarm and Repeater Circuits
F2362S17	TRE	4H	YES
	S20.1	S20.2	

S20.1 *Type*—Temperature measurement equipment shall be designated by the three letter symbols as follows:

TRE—Temperature Resistance Equipment, platinum

TTE—Temperature Thermocouple Equipment, type K

S20.2 *Input Range*—The temperature range in degrees Fahrenheit (°F) shall be designated by its numerical value (see S20.2.1.1 and S20.2.2.1).

S20.2.1 *Temperature Resistance (Type TRE) Input:*

S20.2.1.1 *Ranges*—Equipment temperature range shall be as specified in the acquisition requirements. Ranges shall be in accordance with the following:

Range	Designation
-40 to 127°C (-40° to 260°F)	26
-18 to 205°C (0° to 400°F)	4H
-18 to 538°C (0° to 1000°F)	1K

S20.2.1.2 *Excitation Current*—The maximum current through the resistance temperature element shall be 6 ma, dc.

S20.2.1.3 *Lead Wire Resistance Compensation*—The equipment input for resistance sensing technique shall be of three-wire configuration. A means shall be provided to compensate for the factors which introduce error such as self heating and the resistance of interconnecting wiring between the sensor and signal conditioner.

S20.2.2 *Temperature Thermocouple (Type TCE) Input:*

S20.2.2.1 *Ranges*—Equipment temperature range shall be as specified in the acquisition requirements. Ranges shall be in accordance with the following:

Range	Designation
-40 to 93°C (-40° to 200°F)	2H
-18 to 205°C (0° to 400°F)	4H
-18 to 538°C (0° to 1000°F)	1K
205 to 649°C (400° to 1200°F)	12H
260 to 816°C (500° to 1500°F)	15H

S20.2.2.2 *Cold Junction Compensation*—Cold junction compensation for thermocouple sensing technique shall be automatic and shall be referenced to 0°C (32°F).

S21. Ordering Information

S21.1 The purchaser shall provide the manufacturer with all of the pertinent application data shown in accordance with S21.2. If special application operating conditions exist that are not shown in the acquisition requirements, they shall also be described.

S21.2 *Acquisition Requirements*—Acquisition documents should specify the following:

(1) Title, number and date of this specification,
(2) Classification required,
(3) Quantity of units required,
(4) Type of enclosure mounting,
(5) Power requirements,
(6) Equipment temperature ranges,
(7) Disposition of qualification test samples,
(8) Product marking requirements, and
(9) Unique preservation, packaging, and marking requirements.

S22. Materials and Manufacture

S22.1 Except where specifications are referenced, materials shall be in accordance with commercial specifications having material compositions suitable for service in the shipboard marine environment.

S23. Physical Properties

S23.1 *Description*—The equipment specified herein in conjunction with the thermocouples or resistance temperature elements specified in Appendix B comprise a temperature instrument. The temperature measurement equipment generally consists of the following units:

(1) Signal Conditioner—The signal conditioner shall convert the sensing element output to a continuous linear analog signal directly proportional to temperature.

(2) Power Supply—The power supply shall provide excitation energy to the signal conditioner and sensor.

(3) Test Device—A test device shall be furnished to provide a calibrated test signal used for calibrating the equipment.

The various assemblies of temperature measurement equipment shall be built integrally together and housed in the same enclosure.

S23.2 *Output*—The electrical signal output of the equipment shall be dc, directly proportional to temperature input. The output shall be 4 to 20 ma, dc into an external resistance of 550 ± 10 % σ.

S23.3 *Calibration Means*—A means shall be provided to monitor equipment output corresponding to temperature input to permit in place calibration by one man. Each temperature instrument shall contain a test switch and a temperature detector simulator capable of supplying a test signal into the instrument circuitry. This test device shall have a calibrated dial and shall replace the detector when the instrument is in the test mode. The signal from this simulator shall be of sufficient accuracy to determine static error band (see S24.2) and repeatability (see S24.3). Test jacks shall be provided to monitor the equipment output and detector output. Placing the instrument in the test mode shall allow remote monitoring of the detector. Calibration shall be effected without the necessity of electrical disconnection.

S23.4 *Equipment Range*—Equipment range shall be determined by means of an interchangeable assembly or internal adjustments.

S23.5 *Adjustments*—Tamper-proof adjustments for zero and span shall be provided for calibration purposes. The number of adjustments shall be kept to a minimum, consistent with the operation and maintenance of the equipment and the elimination for the selective matching of parts.

S23.6 *Fail Safe Output*—If the input of the signal conditioner is open circuited, the output shall drive upscale or downscale, the choice of which shall be made by means of a link.

S23.7 *Isolation*—Input and output circuits shall be isolated from each other and from ground.