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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 standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

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:

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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