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An American National Standard

Standard Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Cable[1]

This standard is issued under the fixed designation E839; 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.

1. Scope

1.1 This document lists methods for testing Mineral-Insulated, Metal-Sheathed (MIMS) thermocouple assemblies and thermocouple cable, but does not require that any of these tests be performed nor does it state criteria for acceptance. The acceptance criteria are given in other ASTM standard specifications that impose this testing for those thermocouples and cable. Examples from ASTM thermocouple specifications for acceptance criteria are given for many of the tests. These tabulated values are not necessarily those that would be required to meet these tests, but are included as examples only.

1.2 These tests are intended to support quality control and to evaluate the suitability of sheathed thermocouple cable or assemblies for specific applications. Some alternative test methods to obtain the same information are given, since in a given situation, an alternative test method may be more practical. Service conditions are widely variable, so it is unlikely that all the tests described will be appropriate for a given thermocouple application. A brief statement is made following each test description to indicate when it might be used.

1.3 The tests described herein include test methods to measure the following properties of sheathed thermocouple material and assemblies.

1.3.1 *Insulation Properties:*

1.3.1.1 *Compaction*—direct method, absorption method, and tension method.

1.3.1.2 *Thickness.*

1.3.1.3 *Resistance*—at room temperature and at elevated temperature.

1.3.2 *Sheath Properties:*

1.3.2.1 *Integrity*—two water test methods and mass spectrometer.

1.3.2.2 *Dimensions*—length, diameter, and roundness.

1.3.2.3 *Wall thickness*.

1.3.2.4 *Surface*—gross visual, finish, defect detection by dye penetrant, and cold-lap detection by tension test.

1.3.2.5 *Metallurgical structure*.

1.3.2.6 *Ductility*—bend test and tension test.

1.3.3 *Thermoelement Properties:*

1.3.3.1 *Calibration*.

1.3.3.2 *Homogeneity*.

1.3.3.3 *Drift*.

1.3.3.4 *Thermoelement diameter, roundness, and surface appearance*.

1.3.3.5 *Thermoelement spacing*.

1.3.3.6 *Thermoelement ductility*.

1.3.3.7 *Metallurgical structure*.

1.3.4 *Thermocouple Assembly Properties:*

1.3.4.1 *Dimensions*—length, diameter, and roundness.

1.3.4.2 *Surface*—gross visual, finish, reference junction end moisture seal, and defect detection by dye penetrant.

1.3.4.3 *Electrical*—continuity, loop resistance, and connector polarity.

1.3.4.4 *Radiographic inspection*.

1.3.4.5 *Thermoelement diameter*.

1.3.4.6 *Thermal response time*.

1.3.4.7 *Thermal cycle*.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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.*

[1] These test methods are under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.14 on Thermocouples - Testing.

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2. Referenced Documents

2.1 *ASTM Standards:*[2]

E3 Guide for Preparation of Metallographic Specimens
E94 Guide for Radiographic Examination Using Industrial Radiographic Film
E112 Test Methods for Determining Average Grain Size
E165 Practice for Liquid Penetrant Testing for General Industry
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E207 Test Method for Thermal EMF Test of Single Thermoelement Materials by Comparison With Reference Thermoelement of Similar EMF-Temperature Properties
E220 Test Method for Calibration of Thermocouples By Comparison Techniques
E230 Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
E235 Specification for Type K and Type N Mineral-Insulated, Metal-Sheathed Thermocouples for Nuclear or for Other High-Reliability Applications
E344 Terminology Relating to Thermometry and Hydrometry
E585/E585M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Base Metal Thermocouple Cable
E608/E608M Specification for Mineral-Insulated, Metal-Sheathed Base Metal Thermocouples
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E780 Test Method for Measuring the Insulation Resistance of Mineral-Insulated, Metal-Sheathed Thermocouples and Mineral-Insulated, Metal-Sheathed Cable at Room Temperature
E1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiography
E1129/E1129M Specification for Thermocouple Connectors
E1350 Guide for Testing Sheathed Thermocouples, Thermocouple Assemblies, and Connecting Wires Prior to, and After Installation or Service
E1684 Specification for Miniature Thermocouple Connectors
E1751 Guide for Temperature Electromotive Force (emf) Tables for Non-Letter Designated Thermocouple Combinations
E2181/E2181M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Noble Metal Thermocouples and Thermocouple Cable

2.2 *ANSI Standard*

B 46.1 Surface Texture[3]

2.3 *Other Standard*

USAEC Division of Reactor Development and Technology RDT Standard C 2-1T Determination of Insulation Compaction in Ceramic Insulated Conductors August 1970

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E344 shall apply to these test methods.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bulk cable, n*—a single length of thermocouple cable produced from the same raw material lots after completion of fabrication.

3.2.2 *cable lot, n*—a quantity of finished mineral–insulated, metal-sheathed thermocouple cable manufactured from tubing or other sheath material from the same heat, wire from the same spool and heat, and insulation from the same batch, then assembled and processed together under controlled production conditions to the required final outside diameter.

3.2.3 *cold-lap, n*—sheath surface defect where the sheath surface has been galled and torn by a drawing die and the torn surface smoothed by a subsequent diameter reduction.

3.2.4 *insulation compaction density, n*—the density of a compacted powder is the combined density of the powder particles and the voids remaining after the powder compaction. Sometimes the insulation compaction density is divided by the theoretical density of the powder particles to obtain a dimensionless fraction of theoretical density as a convenient method to express the relative compaction.

3.2.5 *raw material, n*—tubing or other sheath material, insulation and wires used in the fabrication of sheathed thermocouple cable.

3.2.6 *short range ordering, n*—the reversible short-ranged, order-disorder transformation in which the nickel and chromium atoms occupy specific (ordered) localized sites in the Type EP or Type KP thermoelement alloy crystal structure.

3.2.7 *thermal response time, n*—the time required for a sheathed thermocouple signal to attain the specified percent of the total voltage change produced by a step change of temperature at the sheath's outer surface.

4. Summary of Test Methods

4.1 *Insulation Properties:*

4.1.1 *Compaction*—These tests ensure that the insulation is compacted sufficiently (*1*) to prevent the insulation from shifting during use with the possibility of the thermoelements shorting to each other or to the sheath, and (*2*) to have good heat transfer between the sheath and the thermoelements.

4.1.2 *Insulation Resistance*—The insulation shall be free of moisture and contaminants that would compromise the voltage-temperature relationship or shorten the useful life of the sheathed thermocouple. Measurement of insulation resistance is a useful way to detect the presence of unacceptable levels of impurities in the insulation.

4.2 *Sheath Properties:*

4.2.1 *Integrity*—These tests ensure that (*1*) the sheath will be impervious to moisture and gases so the insulation and

[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.

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