Designation: E585/E585M – 18

Standard Specification for Compacted Mineral-Insulated, Metal-Sheathed, Base Metal Thermocouple Cable[1]

This standard is issued under the fixed designation E585/E585M; 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 specification establishes requirements for compacted, mineral-insulated, metal-sheathed (MIMS), base metal thermocouple cable,[2] with at least two thermoelements.[3]

1.2 This specification describes the required material, processing and testing requirements, optional supplementary testing, quality assurance, and verification choices.

1.3 The material of construction includes standard base metal thermoelements, austenitic stainless steel or other corrosion resistant sheath material, and either magnesia (MgO) or alumina (Al_2O_3) insulation.

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.*

2. Referenced Documents

2.1 The following documents of the latest issue form a part of this specification to the extent specified herein. In the event of a conflict between this specification and other specifications referenced herein, this specification shall take precedence.

2.2 *ASTM Standards:*[4]

A213/A213M Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes

A249/A249M Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes

A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service

A632 Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service

B163 Specification for Seamless Nickel and Nickel Alloy Condenser and Heat-Exchanger Tubes

B167 Specification for Nickel-Chromium-Iron Alloys (UNS N06600, N06601, N06603, N06690, N06693, N06025, N06045, and N06696), Nickel-Chromium-Cobalt-Molybdenum Alloy (UNS N06617), and Nickel-Iron-Chromium-Tungsten Alloy (UNS N06674) Seamless Pipe and Tube

B423 Specification for Nickel-Iron-Chromium-Molybdenum-Copper Alloy (UNS N08825, N08221, and N06845) Seamless Pipe and Tube

B516 Specification for Welded Nickel-Chromium-Iron Alloy (UNS N06600, UNS N06601, UNS N06603, UNS N06025, UNS N06045, UNS N06690, and UNS N06693) Tubes

E112 Test Methods for Determining Average Grain Size

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

E230 Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples

E235 Specification for Thermocouples, Sheathed, Type K and Type N, for Nuclear or for Other High-Reliability Applications

[1] This specification is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.12 on Thermocouples - Specifications.

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[2] The terms "MIMS cable", or "thermocouple cable", or "MIMS thermocouple cable", or "cable" will be used herein to describe mineral-insulated, metal-sheathed, base metal thermocouple cable.

[3] "Wire" is also used to describe "thermoelements."

[4] 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.

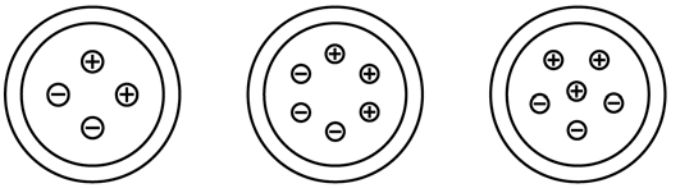

FIG. 1 Examples of Adjacent Configurations

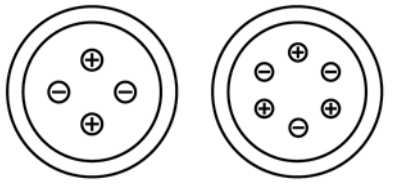

FIG. 2 Examples of Alternating Configurations

E344 Terminology Relating to Thermometry and Hydrometry
E608 Specification for Mineral-Insulated, Metal-Sheathed Base Metal Thermocouples
E780 Test Method for Measuring the Insulation Resistance of Mineral-Insulated, Metal-Sheathed Thermocouples and Mineral-Insulated, Metal-Sheathed Cable at Room Temperature
E839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Cable
E1652 Specification for Magnesium Oxide and Aluminum Oxide Powder and Crushable Insulators Used in the Manufacture of Base Metal Thermocouples, Metal-Sheathed Platinum Resistance Thermometers, and Noble Metal Thermocouples

2.3 *ANSI Standard:*

ANSI B46.1 Surface Texture[5]

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E344 shall apply to this specification.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *adjacent thermoelement configuration, n*—thermoelement configuration within a multi-pair cable where two or more positive thermoelements are immediately adjacent to one another around the circular pattern and two or more negative thermoelements are also immediately adjacent to one another around the circular pattern as shown in Fig. 1 (compare with alternating thermoelement configuration in Fig. 2).

3.2.1.1 *Discussion*—By default, a multi-pair cable with a thermoelement in the center must be considered an adjacent configuration.

3.2.2 *alternating thermoelement configuration, n*—thermoelement configuration within a multi-pair cable where positive thermoelements and negative thermoelements alternate around the circular pattern as shown in Fig. 2 (compare with adjacent thermoelement configuration in Fig. 1).

3.2.2.1 *Discussion*—In an alternating thermoelement pattern, there are never two or more positive thermoelements nor two or more negative thermoelements immediately adjacent to one another.

3.2.3 *lot, n*—a quantity of finished MIMS thermocouple cable manufactured from tubing 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.

3.2.4 *raw material, n*—tubing, insulation, and wires used in fabrication of the MIMS thermocouple cable.

4. Significance and Use

4.1 *Thermocouple Cable may be used as follows:*

4.1.1 Sheathed thermocouple cable for use in manufacturing thermocouples (see Specification E608).

4.1.2 Sheathed thermocouple cable for use as extension cable in extremely harsh environments.

5. Ordering Information and Basis for Purchase

5.1 The purchasing documents shall specify the following options:

5.1.1 The total length of finished thermocouple cable and the length of each piece of finished thermocouple cable.

5.1.2 The type and quantity of thermoelements, the thermoelement configuration (see 3.2.1 and 3.2.2), and the tolerance range for initial values of emf versus temperature if other than standard (see 6.2). Consult individual manufacturers for the number of thermoelements limited by cable size.

5.1.3 The sheath material (see 7.3) and whether it shall be seamless or welded and drawn. Note that other sheath material may be used with purchaser and producer agreement.

5.1.4 The nominal outside diameter of the sheath (see 6.3).

5.1.5 The composition of mineral oxide insulation (see 7.2). Note that other insulation composition(s) and impurity levels may be used with purchaser and producer agreement.

5.1.6 The intended operating temperature range of the cable (see 9.8).

5.1.7 The method used to seal the open ends, prior to shipment (see 11.1).

5.1.8 Supplementary testing or material requirements (see Supplementary Requirements).

5.1.9 The quality assurance or verification program requirements or both (see Appendix X1).

5.1.10 Any deviations from this specification or the referenced documents.

6. General Requirements

6.1 *MIMS Thermocouple Cable*—Cable shall be in accordance with this specification (see Fig. 3). This figure describes a cable with two thermoelements, but more than two thermoelements may be specified.

6.2 *Tolerances on Initial Values of Emf versus Temperature*—The standard tolerances of Specification E230 apply unless otherwise stated in the ordering information.

6.3 *Dimensions*—The dimensional and tolerance requirements for sheath diameter and wall thickness, thermoelement diameter, and insulation thickness depicted in Fig. 3 shall be

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

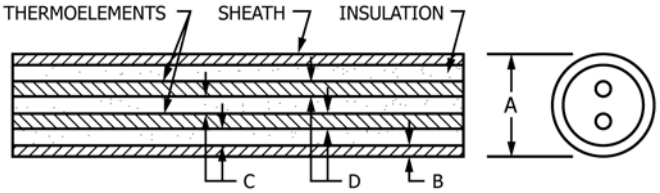

FIG. 3 MIMS Thermocouple Material Construction (See Table 1)

based on nominal sheath outside diameters and number of thermoelements. The preferred cable sizes and sheath diameter tolerances are listed in Table 1. The minimum dimensional requirements for sheath wall thickness, thermoelement diameter, and insulation thickness are summarized in Table 2. The purchaser need only specify the outside diameter and number of thermoelements in the ordering documents.

6.3.1 *Sheath Diameter*—For any nominal sheath size, the outside diameter tolerance, *A*, shall be ±0.025 mm [0.001 in.] or ±1 %, whichever is greater.

6.3.2 *Sheath Wall Thickness*—The wall thickness, *B*, shall be at least 10 % of the nominal sheath outside diameter and shall be uniform within 20 % of the minimum required wall thickness.

6.3.3 *Thermoelement Diameter*—The thermoelement diameter, *D*, shall be at least 15 % of the nominal sheath outside diameter if two thermoelements are included, at least 12 % of the nominal sheath outside diameter if four thermoelements are included, or at least 9 % of the nominal sheath outside diameter if six thermoelements are included. All thermoelement diameters shall be uniform within 20 % of their minimum required diameters.

6.3.4 *Insulation Thickness*—The insulation thickness, *C*, either thermoelement to thermoelement or thermoelement to inside surface of the sheath, shall be at least 7 % of the nominal sheath outside diameter if two thermoelements are included, at least 5.5 % of the nominal sheath outside diameter if four thermoelements are included, or at least 4 % of the nominal sheath outside diameter if six thermoelements are included.

6.3.5 *Sheath Inside Diameter*—The inside sheath diameter is equal to Diameter *A* minus two times dimension *B*. Dimensions shall be measured in accordance with Test Methods E839.

6.4 *Materials*—The thermocouple cable shall be fabricated from component parts specified in Section 7.

6.5 *Insulation Resistance at Room Temperature*—The minimum electric insulation resistance between thermoelements and between each thermoelement and the sheath (at room temperature) shall be as specified in Table 3, for the voltages noted. The values of insulation resistance, given in megohms, shall apply to the supplied lengths. See Test Methods E780 and E839.

6.6 *Minimum Insulation Density*—The minimum density of the compacted electrical insulation shall be 70 % of the maximum theoretical density which is 3580 kg/m^3 [0.129 lb/in.^{3}] for MgO, and 3970 kg/m^3 [0.144 lb/in.^{3}] for Al_2O_3.[6] See also Supplementary Requirement S6.1.

TABLE 1 Dimensions and Tolerances of MIMS Cable in SI (Metric) and Inch-Pound Units

Preferred Sizes—Nominal Outside Diameter, A, in millimetres [inches] Diameters listed below are commonly available sizes.	
Diameter	
millimetres	inches
0.50	0.020
. . .	0.032
1.00	0.040
1.50	0.062
2.00	. . .
. . .	0.093
3.00	0.125
4.50	0.188
6.00	0.250
8.00	0.375

TABLE 2 Summary of Thermocouple Cable Dimensional Requirements (Percent of Nominal Outside Diameter)

Number of Thermoelements	2	4	6
Minimum Sheath Thickness	10 %	10 %	10 %
Minimum Thermoelement Diameter	15 %	12 %	9 %
Minimum Insulation Thickness	7 %	5.5 %	4 %

TABLE 3 Room-Temperature Insulation Resistance Requirements in SI (Metric) and Inch-Pound Units

Nominal Sheath Outside Diameter	Applied Voltage, min, V, dc	Insulation Resistance, min, MΩ
Less than 0.80 mm [0.030 in.]	50	1000
0.80 to 1.45 mm [0.030 to 0.057 in.]	50	5000
Larger than 1.45 mm [0.057 in.]	500	10 000

6.7 *Sheath Condition*—The sheath shall be free of visible surface contaminants and oxidation. The sheath shall be in the fully annealed state for Type E, J, K, and N thermocouple material. For Type T material, the sheath shall be annealed to the extent that the thermoelements will permit. Tests for proving conformance are in Supplementary Requirement S2 or S9.

6.8 *Sheath Integrity*—The sheath of the finished thermocouple cable shall exclude gases and liquids. There shall be no holes, cracks, or other void defects that penetrate through the sheath wall. Tests for proving conformance to this requirement are in Supplementary Requirement S3.

6.9 Quality verification requirements are specified on an optional basis. The purchaser may require material traceability, as desired (see Appendix X1).

6.10 The tests in this specification are the minimum to determine if the specification requirements have been met. Additional optional supplementary requirements are listed in the Supplementary Requirements section and may be included in the purchase order requirements, if desired by the purchaser.

[6] *Handbook of Chemistry and Physics*, Chemical Rubber Publishing Co., No. 76 (1995) edition.