Designation: E 585/E 585M – 99

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

This standard is issued under the fixed designation E 585/E 585M; 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, base metal thermocouple cable,[2] with at least two thermoelements.[3]

1.2 This specification describes the required material, processing and testing requirements, and also the optional supplementary testing and 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 inch-pound units or SI (metric) units may be regarded separately as standard. The values stated in each system are not the exact equivalents, and each system shall be used independently of the other.

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 and health practices and determine the applicability of regulatory limitations prior to use.*

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:*

A 213/A 213M Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes[4]

A 249/A 249M Specification for Welded Austenitic Steel Boiler, Superheater, Heat-Exchanger, and Condenser Tubes[4]

A 269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service[4]

A 632 Specification for Seamless and Welded Austenitic Stainless Steel Tubing (Small-Diameter) for General Service[4]

B 163 Specification for Seamless Nickel and Nickel Alloy Condenser and Heat-Exchanger Tubes[5]

B 167 Specification for Nickel-Chromium-Iron Alloy (UNS N06600, N06601, and N06690) Seamless Pipe and Tube[5]

B 516 Specification for Welded Nickel-Chromium-Iron Alloy (UNS N06600, UNS N06603, UNS N06025, and UNS N06045) Tubes[5]

E 220 Method for Calibration of Thermocouples by Comparison Techniques[6]

E 230 Specification for Temperature—Electromotive Force (EMF) Tables for Standardized Thermocouples[6]

E 235 Specification for Thermocouples, Sheathed, Type K, for Nuclear or for Other High-Reliability Applications[6]

E 344 Terminology Relating to Thermometry and Hydrometry[6]

E 608 Specification for Metal-Sheathed Base-Metal Thermocouples[6]

E 780 Test Method for Measuring the Insulation Resistance of Sheathed Thermocouple Material at Room Temperature[6]

E 839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Material[6]

E 1652 Specification for Magnesium Oxide and Aluminum Oxide Powder and Crushable Insulators used in the Manufacture of Metal-Sheathed Platinum Resistance Thermometers and Noble Metal Thermocouples[6]

2.3 *ANSI Standard:*

B46.1 Surface Texture[7]

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E 344 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

[1] This specification is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.04 on Thermocouples.

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[2] The terms "metal sheathed thermocouple cable" or "cable" will be used to describe the subject description.

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

[4] *Annual Book of ASTM Standards*, Vol 01.01.

[5] *Annual Book of ASTM Standards*, Vol 02.04.

[6] *Annual Book of ASTM Standards*, Vol 14.03.

[7] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

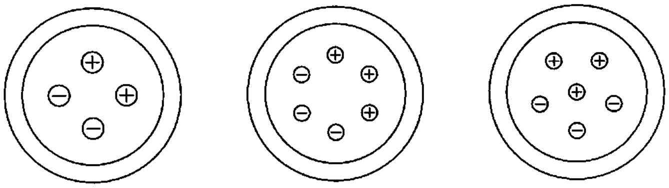

FIG. 1 Examples of Adjacent Configurations

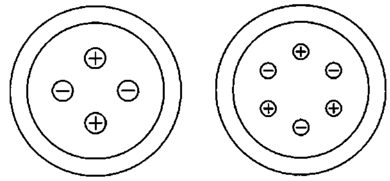

FIG. 2 Examples of Alternating Configurations

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 mineral-insulated, metal-sheathed 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 sheathed 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 E 608).

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 on 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 kind of 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 kind of ceramic insulation (see 7.2). Note that other insulation composition 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 kind of end seal applied to 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 *Mineral-Insulated, Metal–Sheathed 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 E 230 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 based on nominal sheath outside diameters. The preferred cable sizes are listed in Table 1. For any nominal sheath size, the outside diameter tolerance, *A*, shall be ±0.025 mm [0.001 in.] or ±1 %, whichever is greater. The wall thickness, *B*, shall be at least 10 % of the nominal sheath outside diameter and shall be uniform within 20 %. The thermoelement diameters, *D*, shall be at least 15 % of the nominal sheath outside diameter if 2 thermoelements are included, at least 12 % of the nominal sheath outside diameter if 4 thermoelements are included, or at least 9 % of the nominal sheath outside diameter if 6 thermoelements are included. The insulation thickness, *C*, either thermoelement to thermoelement or thermoelement to inside surface of the sheath, shall be at least 10% of the inside diameter of the sheath. The inside sheath diameter is equal to Diameter *A* minus 2 times dimension *B*. Dimensions shall be measured per Test Methods E 839. The purchaser need only specify the outside diameter and number of thermoelements in the ordering documents.

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 2, for the voltages noted. The values of insulation resistance, given in megohms, shall apply to the supplied lengths. See Test Methods E 780 and E 839.

6.6 *Minimum Insulation Density*—The minimum density of the compacted electric insulation shall be 70 % of the maximum theoretical density which is 3580 kg/m^3[0.129 lb/in.^{3}] for

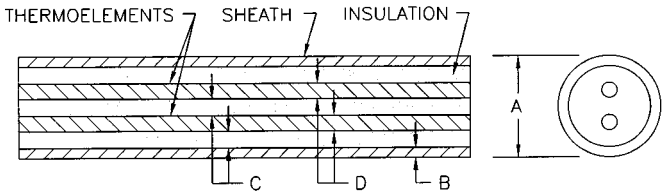

FIG. 3 Sheathed Thermocouple Material Construction (See Table 1)

TABLE 1 Dimensions of Metal Sheathed Thermocouple Cable in SI (Metric) and Inch-Pound Units

Preferred Sizes—Nominal Outside Diameter, A, in millimetres [inches]	
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 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

MgO, and 3970 kg/m^3[0.144 lb/in.^{3}] for Al_2O_3.[8] See also Supplementary Requirement S6.2.

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 as specified in the body of the 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 purchasing order requirements, as desired by the purchaser.

7. Material Requirements

7.1 *Thermoelements*:

7.1.1 The thermoelements shall be solid wire, round in cross section.

7.1.2 The thermoelements shall only be of thermoelectric types: E, J, K, N, or T. All wire used for fabrication shall meet the supplemental cleanliness requirements of Specification A 632, except that no acetone shall be used as a cleaning agent.

7.1.3 The emf versus temperature relationship shall meet the initial calibration tolerance of 6.2.

7.2 *Insulation*:

7.2.1 The insulation shall only be magnesia (MgO) or alumina (Al_2O_3) and shall meet the compositional requirements specified in 7.2.1.1 or 7.2.1.2.

7.2.1.1 The magnesia, if used, shall be electrically fused with a 99.4 % minimum mass content of magnesia. All impurity concentrations in the magnesia shall be less than 0.6% by mass. The total iron impurity concentration expressed as Fe_2O_3 shall not exceed 0.04% by mass. The sulfur content shall be less than 0.005% by mass, and the carbon content shall not exceed 0.02% by mass. Magnesia powders and crushable insulators conforming to Specification E 1652 satisfy these requirements.

7.2.1.2 The alumina, if used, shall be alpha alumina with a minimum mass content of 99.5 % alumina. All impurity concentrations in the alumina shall be less than 0.5% by mass. Sulfur shall not exceed 0.005% by mass while carbon shall not exceed 0.02% by mass. Alumina powders and crushable insulators conforming to Specification E 1652 satisfy these requirements.

7.3 *Sheath Material*:

7.3.1 The sheath material may be seamless or welded and drawn tubing of austenitic stainless steel, or heat-resistant nickel-chrome-iron alloy.

7.3.2 The producer's customary tubing specification shall be applicable for the sheath material. See Supplementary Requirement S8.

7.3.3 A nickel-chrome-iron sheath, as in Specifications B 163, B 167, or B 516, is recommended for fresh water service. There are high molybdenum stainless steels that are specifically made for use in salt water, such as type 316 and proprietary alloys.

7.3.4 Alternate heat-resistant tubing materials may be specified for the sheath by the producer, provided the annealing requirements imposed by 6.7 are satisfied.

7.3.5 Each piece of tubing used in the fabrication of thermocouple material shall meet the supplemental cleanliness requirements of Specification A 632, except that acetone may not be used as a cleaning agent.

8. Processing Requirements

8.1 The producer is responsible for all processing of all component materials to ensure that the overall requirements of this specification are met. The producer is also responsible for the quality of the finished product.

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