Designation: E 235 – 03

# Standard Specification for Thermocouples, Sheathed, Type K and Type N, for Nuclear or for Other High-Reliability Applications[1]

This standard is issued under the fixed designation E 235; 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 covers the requirements for sheathed, Type K and N thermocouples for nuclear service. Depending on size, these thermocouples are normally suitable for operating temperatures to 1652 °F (900 °C); special conditions of environment and life expectancy may permit their use at temperatures in excess of 2012 °F (1100 °C). This specification was prepared specifically to detail requirements for using this type of sheathed thermocouple in nuclear environments. This specification can be used for sheathed thermocouples which are required for laboratory or general commercial applications where the environmental conditions exceed normal service requirements. The intended use of a sheathed thermocouple in a specific nuclear application will require evaluation by the purchaser of the compatibility of the thermocouple, including the effect of the temperature, atmosphere, and integrated neutron flux on the materials and accuracy of the thermoelements in the proposed application. This specification does not attempt to include all possible specifications, standards, etc., for materials that may be used as sheathing, insulation, and thermocouple wires for sheathed-type construction. The requirements of this specification include only the austenitic stainless steels and other alloys as allowed with Specification E 585/E 585M for sheathing, magnesium oxide or aluminum oxide as insulation, and Type K and N thermocouple wires for thermoelements (see Note 1).

1.2 *General Design*—Nominal sizes of the finished thermocouples shall be 0.0400 in. (1.016 mm), 0.0625 in. (1.588 mm), 0.125 in. (3.175 mm), 0.1875 in. (4.763 mm), or 0.250 in. (6.350 mm). Sheath dimensions and tolerances for each nominal size shall be in accordance with Table 1. The classes of thermocouples covered by this specification are as follows:

1.2.1 *Class 1 (grounded)*—Measuring junction electrically connected to conductive sheaths, and

1.2.2 *Class 2 (ungrounded)*—Measuring junctions are electrically isolated from conductive sheaths and from reference ground.

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

1.4 *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 *ASTM Standards:* [2]

A 262 Practices for Detecting Susceptibility to Intergranular Attack in Austenitic Stainless Steels

E 3 Practice for Preparation of Metallographic Specimens

E 45 Test Methods for Determining the Inclusion Content of Steel

E 94 Guide for Radiographic Examination

E 112 Test Methods for Determining Average Grain Size

E 165 Test Method for Liquid Penetrant Examination

E 220 Test Method for Calibration of Thermocouples by Comparison Techniques

E 230 Specification for Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples

E 344 Terminology Relating to Thermometry and Hydrometry

E 585/E 585M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Base Metal Thermocouple Cable

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

E 839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Material

E 883 Guide for Reflected-Light Photomicrography

E 1652 Specification for Magnesium Oxide and Aluminum Oxide Powder and Crushable Insulators Used in the Manufacture of Metal-Sheathed Platinum Resistance Thermometers, Base Metal Thermocouples, and Noble Metal Thermocouples

[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.

Current edition approved Nov. 1, 2003. Published January 2004. Originally approved in 1964. Last previous edition approved in 1996 as E 235 – 88 (1996)$^{\epsilon 1}$.

[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.

**TABLE 1 Dimensions for Class 1 and 2 Measuring Junctions**

| Sheath Outside Diameter, *A* | | | Minimum Sheath Wall, *B* | Minimum Insulation Thickness, *C* | Minimum Wire Diameter, *D* | *E*, Tolerance | | *F*, Tolerance | |
|---|---|---|---|---|---|---|---|---|---|
| Nominal | Tolerance | | | | | min | max | min | max |
| | min | max | | | | | | | |
| Inches | | | | | | | | | |
| 0.0400 | 0.0390 | 0.0415 | 0.006 | 0.004 | 0.005 | 0.006 | 0.020 | 0.004 | 0.021 |
| 0.0625 | 0.0615 | 0.0640 | 0.009 | 0.005 | 0.010 | 0.009 | 0.032 | 0.005 | 0.032 |
| 0.1250 | 0.1240 | 0.1265 | 0.012 | 0.012 | 0.020 | 0.012 | 0.062 | 0.012 | 0.063 |
| 0.1875 | 0.1865 | 0.1890 | 0.020 | 0.022 | 0.031 | 0.020 | 0.093 | 0.022 | 0.095 |
| 0.2500 | 0.2480 | 0.2520 | 0.030 | 0.024 | 0.040 | 0.030 | 0.125 | 0.024 | 0.125 |
| Millimetres | | | | | | | | | |
| 1.016 | 0.991 | 1.054 | 0.15 | 0.10 | 0.13 | 0.15 | 0.51 | 0.10 | 0.53 |
| 1.588 | 1.562 | 1.626 | 0.23 | 0.13 | 0.25 | 0.23 | 0.81 | 0.13 | 0.81 |
| 3.175 | 3.150 | 3.213 | 0.30 | 0.30 | 0.51 | 0.30 | 1.57 | 0.30 | 1.60 |
| 4.763 | 4.737 | 4.801 | 0.51 | 0.56 | 0.79 | 0.51 | 2.36 | 0.56 | 2.41 |
| 6.350 | 6.299 | 6.401 | 0.76 | 0.61 | 1.02 | 0.76 | 3.18 | 0.61 | 3.18 |

2.2 *ANSI Standard:*

B46.1 Surface Texture[3]

2.3 *American Welding Society Standard:*

A5.9 Specification for Corrosion-Resisting Chromium and Chromium-Nickel Steel-Welding Rods and Bare Electrodes[4]

## 3. Terminology

3.1 The definitions given in Terminology E 344 shall apply to this specification.

## 4. Ordering Information and Basis of Purchase

4.1 The purchase order documents shall specify the following information:

4.1.1 The quantity, length, and nominal diameter of the sheathed thermocouple,

4.1.2 The thermocouple type and tolerance on initial values of emf versus temperature, if other than standard (see Specification E 230),

4.1.3 The type of ceramic insulation required, either alumina ($Al_2O_3$) or magnesia (MgO),

4.1.4 The type of sheath material and other information required (see 5.1.1),

4.1.5 The class of thermocouple measuring junction,

4.1.6 The type of dye-penetrant inspection procedure to be used, and

4.1.7 Any deviations from this specification or the referenced specifications.

## 5. Materials and Manufacture

5.1 All materials used shall be in accordance with the following requirements:

5.1.1 *Sheath Materials*—The sheath material used for the thermocouples described in this specification must meet the requirements of Specification E 585/E 585M. The purchaser of the thermocouples shall specify only the name of the material (seamless or welded), grade, optional requirements, test report required, and ASTM designation.

5.1.1.1 The inclusion level of the tubing shall be determined by mounting a 1-in. minimum length of a longitudinal section of the tubing using Test Methods E 45, Microscopical Method A, for examination. The inclusion level shall be less than 3 A through D, thin or heavy.

5.1.1.2 The grain size of the tubing shall be determined by a specimen taken in accordance with Test Methods E 112. Grain size shall be as specified in Table 2, or finer, as determined by the Comparison Procedure of Test Methods E 112.

5.1.1.3 Each lot of tubing used shall be sampled using Practices A 262 as follows. Samples shall be tested by Practice A, and further tested as outlined by Table 1 in Practices A 262, where screening tests so indicate. Acceptance levels for these tests shall be agreed upon between the purchaser and the producer.

5.1.2 *Thermoelement*—Thermoelements referred to in this specification shall be Type K or Type N with a tolerance on initial values of emf versus temperature specified if other than standard.

NOTE 1—The purchaser may specify an alternative type of thermoelement as designated in Specification E 230 by indicating this deviation in the ordering documents.

5.1.3 *Insulation*—The insulating material shall be either magnesia (MgO) or alumina ($Al_2O_3$) and shall comply with Specification E 1652 Type 1 material requirements:

5.1.3.1 A certified analysis of the composition of the insulating material as supplied to the thermocouple manufacturer shall be furnished to the purchaser. The thermocouple manufacturer shall be responsible for maintaining the purity within the specified limits in the finished product.

**TABLE 2 Maximum Grain Sizes**

| Sheath Outside Diameter, in. (mm) | Maximum |
|---|---|
| 0.0400 (1.016) | 6 |
| 0.0625 (1.588) | 5 |
| 0.1250 (3.175) | |
| 0.1875 (4.763) | |
| 0.2500 (6.35) | |

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

[4] Available from The American Welding Society (AWS), 550 NW LeJeune Rd., Miami, FL 33126.