



Standard 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 Thermocouples¹

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1. Scope

1.1 This specification covers the requirements for magnesium oxide (MgO) and aluminum oxide (Al₂O₃) powders and crushable insulators used to manufacture base metal thermocouples, metal-sheathed platinum resistance thermometers (PRTs), noble metal thermocouples, and their respective cables.

1.2 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.

1.3 *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.*

1.4 *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

B329 Test Method for Apparent Density of Metal Powders and Compounds Using the Scott Volumeter

C809 Test Methods for Chemical, Mass Spectrometric, and Spectrochemical Analysis of Nuclear-Grade Aluminum Oxide and Aluminum Oxide-Boron Carbide Composite Pellets

¹ This specification is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.13 on Thermocouples - Materials and Accessories Specifications.

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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.

C832 Test Method for Measuring Thermal Expansion and Creep of Refractories Under Load

D2766 Test Method for Specific Heat of Liquids and Solids (Withdrawn 2018)³

E228 Test Method for Linear Thermal Expansion of Solid Materials With a Push-Rod Dilatometer

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

E1137/E1137M Specification for Industrial Platinum Resistance Thermometers

E1225 Test Method for Thermal Conductivity of Solids Using the Guarded-Comparative-Longitudinal Heat Flow Technique

E2181/E2181M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Noble Metal Thermocouples and Thermocouple Cable

3. Terminology

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

4. Significance and Use

4.1 Magnesium oxide and aluminum oxide are used to electrically isolate and mechanically support the thermoelements of a thermocouple (see Specifications **E235**, **E585/E585M**, and **E2181/E2181M**) and the connecting wires of a PRT (see Specification **E1137/E1137M**) within a metal sheath. The metal sheath is typically reduced in diameter to compact the oxide powder or crushable oxide insulators around the thermoelements or wires.

³ The last approved version of this historical standard is referenced on www.astm.org.

4.2 In order to be suitable for this purpose, the materials shall meet certain criteria for purity and for mechanical and dimensional characteristics. Material that does not meet the purity criteria may cause premature failure of the sensor.

4.3 Use of this specification for the procurement of powder and crushable insulators will help to ensure that the product obtained is suitable for the intended purpose.

4.4 Useful information about alumina and magnesia is given in the appendixes.

5. Classification

5.1 The purchaser shall specify the appropriate Material and Type from 5.2 through 5.6 below.

5.2 MgO Type 1 in accordance with Table 1.

5.3 Al₂O₃ Type 1 in accordance with Table 1.

5.4 MgO Type 1P in accordance with Table 2.

5.5 Al₂O₃ Type 1P in accordance with Table 2.

5.6 MgO Type 2 in accordance with Table 3.

NOTE 1—There is no corresponding Al₂O₃ Type 2 designation at this time.

5.7 The final product shall be chemically analyzed using appropriate methods listed in 9.1. Major impurities shall not exceed the limits indicated in Table 1 through Table 3 for the appropriate grade. Any detected impurity with a concentration greater than 0.001 % (mass) shall be reported to the purchaser.

6. Ordering Information

6.1 The purchaser shall specify the following when ordering:

6.1.1 *Material and Type in accordance with Section 5.*

6.1.2 *Insulator Outside Diameter.*

6.1.3 *Hole Diameter.*

6.1.4 *Number of Holes.*

6.1.5 *Hole Pattern.*

6.1.6 *Length.*

6.1.7 *Particle Size* (if supplied as powder).

TABLE 1 Chemical Requirements for Al₂O₃ Type 1 and MgO Type 1^{A, B}

Aluminum Oxide (Al ₂ O ₃) 99.65 % (mass) min		Magnesium Oxide (MgO) 99.40 % (mass) min	
Impurity	Concentration, % (mass)	Impurity	Concentration, % (mass)
CaO	0.08 max	CaO	0.35 max
SiO ₂	0.08 max	SiO ₂	0.35 max
MgO	0.08 max	Al ₂ O ₃	0.15 max
Fe ₂ O ₃	0.04 max	Fe ₂ O ₃	0.07 max
ZrO ₂	0.08 max		
Na ₂ O	0.06 max		
C	0.01 max	C	0.02 max
S	0.005 max	S	0.0025 max
B	0.001 max	B	0.0035 max
Cd	0.001 max	Cd	0.001 max
		B+Cd	0.004 max

^A Platinum thermoelements and Noble Metal thermocouples for use above 650 °C shall specify Type 1P composition according to Table 2.

^B Base metal thermocouples for nuclear environments in accordance with Specification E235 shall specify Type 1P composition according to Table 2.

TABLE 2 Chemical Requirements for Al₂O₃ Type 1P and MgO Type 1P^A

Aluminum Oxide (Al ₂ O ₃) 99.65 % (mass) min		Magnesium Oxide (MgO) 99.40 % (mass) min	
Impurity	Concentration, % (mass)	Impurity	Concentration, % (mass)
CaO	0.08 max	CaO	0.35 max
SiO ₂	0.08 max	SiO ₂	0.13 max
MgO	0.08 max	Al ₂ O ₃	0.15 max
Fe ₂ O ₃	0.04 max	Fe ₂ O ₃	0.04 max
ZrO ₂	0.08 max		
Na ₂ O	0.06 max		
C	0.01 max	C	0.02 max
S	0.005 max	S	0.0025 max
B	0.001 max	B	0.0035 max
Cd	0.001 max	Cd	0.001 max
		B+Cd	0.004 max

^A Platinum thermoelements and noble Metal thermocouples for use below 650 °C may optionally specify Type 1 composition according to Table 1.

TABLE 3 Chemical Requirements for MgO Type 2

Magnesium Oxide (MgO) 97.00 % (mass) min	
Impurity	Concentration, % (mass)
CaO	1.50 max
Al ₂ O ₃	1.00 max
SiO ₂	3.00 max
Fe ₂ O ₃	0.15 max
C	0.02 max
S	0.0025 max
B	0.0050 max
Cd	0.001 max
B + Cd	0.0050 max
MgO + CaO + Al ₂ O ₃ + SiO ₂	99.50 min

6.2 The purchaser may specify the following additional information when ordering:

6.2.1 *Minimum Inside Diameter (at Maximum Material Condition (MMC)) of the Tubing*, (into which insulators will be inserted, see 8.3).

6.2.2 *Maximum Outside Diameter of Wire which will be inserted into the insulators*, (see 8.3).

6.3 Consult the insulator manufacturer for limitations of relationships between outside diameter, hole diameters, hole patterns, and length.

7. Physical Properties

7.1 *Density*—The density of crushable magnesium oxide and aluminum oxide insulators typically ranges from 2060 kg/m³ (0.074 lbf/in.³) to 3060 kg/m³ (0.111 lbf/in.³). Specific density requirements, as well as the test method to be used to determine density, shall be negotiated between the purchaser and manufacturer. See Appendix X3 for suggested test methods.

7.2 *Modulus of Rupture (MOR)*—In the past, a breaking force test that is based on a relative modulus of rupture and is related to crushability has been used. However, with variations in modulus from 21 to 83 MPa (3000 to 12 000 lbf/in.²) influenced by insulator configuration, number of holes, and cross-sectional dimensions, specific modulus requirements cannot be listed for each configuration. The modulus of rupture is best used for lot-to-lot comparison of a given insulator size