



Designation: E780 – 06

Standard Test Method for Measuring the Insulation Resistance of Mineral-Insulated, Metal-Sheathed Thermocouples and Thermocouple Cable at Room Temperature¹

This standard is issued under the fixed designation E780; 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 test method provides the procedures for measuring the room temperature electrical insulation resistance between the thermoelements, and between the thermoelements and the sheath, of a mineral-insulated, metal-sheathed thermocouple or thermocouple cable. It may be used to measure the insulation resistance of bulk lengths of thermocouple cable previously sealed against moisture intrusion or to test a thermocouple having an ungrounded class 2 junction. This method cannot be used to test a thermocouple having a grounded class 1 junction unless the junction is removed prior to testing, after which the thermocouple may be dealt with in the same manner as a thermocouple cable.

1.2 This test method applies primarily to thermocouple cables conforming to Specifications E585/E585M and E2181/E2181M and to thermocouples conforming to Specifications E608/E608M and E2181/E2181M, but may also be applied to thermocouples or thermocouple cables that are suitable for use in air, whose sheath or thermoelements are comprised of refractory metals, that are tested in a dry and chemically inert environment, and that may employ compacted ceramic insulating materials other than magnesia (MgO) or alumina (Al_2O_3). Users of this test method should note that specifications dealing with compacted ceramic insulating materials other than magnesia or alumina, which are described in Specification E1652, are not currently available. As a result, acceptance criteria must be agreed upon between the customer and supplier at the time of purchase, or alternatively, judgment and experience must be applied in establishing test voltage levels and acceptable insulation resistance values for these types of thermocouples and thermocouple cables.

1.3 This test method may be used for thermocouples or thermocouple cables having an outside diameter of 0.5 mm (0.020 in) or larger.

1.4 Users of this test method should be aware that the room temperature insulation resistance of a mineral-insulated, metal-sheathed thermocouple or thermocouple cable may change during shipment, storage, or use.

1.5 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.6 *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

E235 Specification for Thermocouples, Sheathed, Type K and Type N, 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

E1652 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

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

¹ This test method 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 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. Terminology

3.1 *Definitions*—The definitions given in Terminology E344 shall apply to the terms used in this test method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bulk material length (BML), n*—a single length of finished thermocouple cable.

3.2.2 *dry, adj*—a condition of the ambient air at time of test that does not exceed the equivalent of 50 % relative humidity at 22°C [72°F].

3.2.3 *thermocouple, n*—refers to a mineral-insulated, metal-sheathed thermocouple.

3.2.4 *thermocouple cable, n*—refers to a mineral-insulated, metal-sheathed thermocouple cable.

4. Summary of Test Method

4.1 This test method measures the room temperature ($22 \pm 5^\circ\text{C}$ ($72 \pm 10^\circ\text{F}$)) dc electrical insulation resistance: (1) in the case of a length of thermocouple cable, between each of the thermoelements and between the thermoelements and the sheath; (2) in the case of either a thermocouple having a single, ungrounded class 2 junction or a thermocouple having multiple thermoelement pairs which share a common, ungrounded class 2 junction, between the thermoelement pair(s) and the sheath; (3) in the case of a thermocouple having multiple, separate, ungrounded class 2 junctions, between each of the thermoelement pairs and between the thermoelement pairs and the sheath. The resistance measurements are made with an instrument such as a megohm bridge or megohmmeter as described in 6.2.

4.2 In general, because removal of the hot junction would be necessary, measurement of the insulation resistance between all thermoelements in a thermocouple is not commonly undertaken and testing is limited to measuring the insulation resistance between thermoelement pairs where possible, and between the thermoelement pairs and the sheath of the thermocouple.

4.3 Special preparation of a thermocouple will not normally be required, provided that the extension lead wires are clean, undamaged, and sufficiently long to permit connection of the test instrument.

4.4 A thermocouple cable having effective end seals in place and its thermoelements accessible may be tested without further preparation. If preparation of the thermocouple cable is required, special precautions may be necessary to prevent the intrusion of moisture and other contaminants that can affect the insulation resistance. The repeatability of the test method can primarily depend upon how well this is achieved. Preparation usually involves removing 10 to 30 mm (0.4 to 1.2 in.) of the sheath from each end of the thermocouple cable, preventing the intrusion of any moisture into, or expelling any moisture from, the compacted mineral insulation, and sealing the ends with epoxy resin or other suitable moisture sealant. Users of this test method may refer to Appendix X1 for information.

5. Significance and Use

5.1 Thermocouples fabricated from thermocouple cable that has been contaminated by moisture or by other impurities may undergo large changes in thermoelectric properties or may fail

catastrophically when exposed to high temperatures. Since such contamination usually lowers the electrical resistance between the thermoelements and the sheath substantially, measurement of the insulation resistance can provide a valuable check of insulation quality and cleanliness, and can serve as a basis for rejection of unsuitable material and unreliable components. For manufacturers in particular, low electrical insulation resistance can also be indicative of displaced thermoelements or defects in the metal sheath which will require further investigation, but all users should be aware of these potential defects when faced with an unacceptable insulation resistance measurement.

5.2 This test method is primarily intended for use by manufacturers and users of mineral-insulated, metal-sheathed thermocouples or thermocouple cables to verify that measured values of insulation resistance exceed specified minimum values, such as those listed in Specifications E235, E585/E585M, E608/E608M, and E2181/E2181M. Manufacturers and users should be aware, however, that when the insulation resistance is greater than $1 \times 10^8 \Omega$, disagreement by an order of magnitude in the results obtained with this test method is not unusual. In addition, users of this test method should appreciate that the room temperature insulation resistance of both thermocouple cables and of finished thermocouples may change during shipment, storage, and use, particularly if the end seals are damaged or defective. Consequently, values of insulation resistance determined by this test method may not necessarily be repeatable.

6. Apparatus

6.1 **Warning**—All tools and apparatus used must be clean and must not introduce oil or other contaminants into the insulation. The presence of such contaminants may invalidate the test results obtained using this test method.

6.2 *Megohmmeter or Megohm Bridge*, with a test voltage range between 50 and 500 VDC, measurement ranges from $1 \times 10^5 \Omega$ to $1 \times 10^{12} \Omega$, and an accuracy of at least $\pm 10\%$ of reading. Both the positive and negative connection terminals and test leads are to be electrically “floating,” that is not connected to earth ground potential.

6.2.1 Other resistance-measuring instruments or circuits that satisfy the electrical requirements given in 6.2 are acceptable.

6.3 *Insulated Copper Connecting Wires*, with suitable mechanical-type connectors.

6.4 The following apparatus may be required in carrying out the procedures described in Appendix X1:

6.4.1 *Heat Source*, (for example, a small propane-type torch or an electric heat gun).

6.4.2 *Moisture Sealant*, such as epoxy resin³ or hot melt glue that when properly applied will provide an effective seal

³ Devcon “5-Minute” Epoxy has been found suitable for this purpose. The sole source of supply of the Devcon “5-Minute” Epoxy known to the committee at this time is Devcon Corp., Endicott St., Danvers, MA 01923. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.