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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Measuring the Insulation Resistance of Sheathed Thermocouple Material at Room Temperature[1]

This standard is issued under the fixed designation E 780; 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 covers the techniques and requirements for measuring the electrical insulation resistance at room temperature between the thermoelements and between each of the thermoelements and the metal sheath of compacted ceramic-insulated, sheathed thermocouple material. It may be used to measure the insulation resistance of bulk lengths of sheathed thermocouple material environmentally sealed at the time of manufacture. It may also be used for testing sheathed thermocouples with a Type U junction. This test method cannot be used for sheathed thermocouples with a Type G junction unless the junction is removed, prior to testing.

1.2 This test method applies to the testing of sheathed thermocouple materials that are suitable for use in air. It is also applicable for sheathed thermocouple materials whose sheath or thermoelements are composed of refractory metals and are tested in a dry and nonreactive environment.

1.3 This test method may be used for sheathed thermocouple material having an outside diameter of 1.0 mm or larger.

1.4 Since the insulation resistance at room temperature of sheathed thermocouple materials may change during shipment, storage and use, the results obtained by this test method may not be the same as insulation resistance values determined at some later time.

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 *ASTM Standards:*

E 235 Specification for Thermocouples, Sheathed, Type K, for Nuclear or for Other High-Reliability Applications[2]

E 344 Terminology Relating to Thermometry and Hydrometry[2]

E 585 Specification for Sheathed Base-Metal Thermocouple Materials[2]

E 608 Specification for Metal-Sheathed Base-Metal Thermocouples[2]

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E 344 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 thermocouple material (produced from the same raw material lot) after completion of fabrication resulting in sheathed thermocouple material.

3.2.2 *dry*, *adj*—a condition which does not exceed the equivalent of 50 % relative humidity at 22°C.

3.2.3 *nonreactive*, *adj*—a condition which will not produce a chemical transformation or change.

3.2.4 *test specimen*, *n*—a short length, at least 300 mm long, cut from the bulk material length.

4. Summary of Test Method

4.1 This test method involves measuring the d-c electrical resistance at normal room temperatures (22 ± 5°C) between the thermoelements and between each of the thermoelements and the metal sheath of a length of sheathed thermocouple material. The resistance measurements are made with an instrument such as a megohm bridge or megohmeter. The instrument must be capable of determining values of resistance from $5 \times 10^4 \Omega$ to $1 \times 10^{12} \Omega$ with an uncertainty of not more than ±10 %. The applied voltage for the resistance measurement is 500 V d-c for sheathed thermocouple material having an outside diameter larger than 1.5 mm, and an applied voltage of 50 V d-c is recommended for smaller diameter sheathed thermocouple materials.

4.2 Special precautions must be exercised when preparing the sheathed thermocouple material for the resistance measurements to prevent the intrusion of moisture and other contaminants that might alter the insulation resistance. The repeatability of the test method depends primarily upon how well this is achieved. Preparation of the sheathed thermocouple material involves removing 5 to 30 mm of the metal sheath from the ends of the sheathed thermocouple material, heating the sheath

[1] This test method is under the jurisdiction of ASTM Committee E-20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.04 on Thermocouples.

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

adjacent to the open ends, and sealing the ends with epoxy resin.

5. Significance and Use

5.1 Thermocouples fabricated from sheathed thermocouple material that has been contaminated by moisture, or by certain other impurities, may undergo large calibration changes or may fail catastrophically when they are heated to high temperatures. Since such contamination usually substantially lowers the electrical resistance between the thermoelements and the sheath, a measurement of the insulation resistance can provide a valuable check on insulation quality and cleanliness, and it can serve as a basis for rejection of unsuitable material.

5.2 This test method is primarily intended for use by the manufacturers and users of sheathed thermocouple materials to verify that the measured values of insulation resistance meet or exceed specified values, such as those listed in Specifications E 235, E 585, and E 608. Both manufacturers and users should be aware, however, that when the insulation resistance is high, above $1 \times 10^6 \Omega$, disagreement by an order of magnitude in results obtained by using this method is not unusual. In addition, users should be aware that the insulation resistance at room temperature of sheathed thermocouple materials and of finished sheathed 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 apply at a later time.

6. Apparatus

6.1 *Megohmeter or Megohm Bridge*, with ranges from $5 \times 10^4 \Omega$ to $1 \times 10^{12} \Omega$ with an accuracy of better than ±10 % of the measured resistance and test voltage of 50 or 500 V d-c, depending upon the outside diameter of the sheathed thermocouple material.

6.1.1 Other resistance-measuring instruments or circuits that satisfy the electrical requirements given in 6.1 are equally acceptable.

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

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

6.4 *Epoxy Resin*, [3] suitable as an environmental seal for the ends of the bulk material length or of the test specimen at temperatures up to 200°C.

6.5 *Metal-Sheathed Cable Stripper*—Any commercially available cable stripper that will satisfactorily remove the sheath without damage to the thermoelements is acceptable.

6.6 *Optical Magnifier*, with a magnification of 5× to 10× (for example, a watchmaker's loupe).

6.7 *Cutting Tools*, such as diagonal cutters or a suitable metal saw may be required, if a test specimen is to be removed for test purposes.

NOTE 1—**Caution:** All tools that are used must be clean and must not introduce oil or other contaminants into the insulation.

7. Test Specimen

7.1 Conduct the test by using an entire bulk length of sheathed thermocouple material or a test specimen removed from it. Determine the test specimen length by the distance from one end of the compacted ceramic insulation to the other.

7.2 In cases where a test specimen is removed for testing, take the test specimen from any location along the bulk material length, provided the ends of the bulk material length were sealed at the time of manufacture. If the ends were unsealed and exposed to ambient surroundings for more than 1 min at any time since manufacture, take the test specimen from a location that is at least 300 mm from the ends. This also applies when the integrity of the end seals is in doubt or when the history of the bulk material length is not known.

8. Procedure

8.1 *Preparation of Sheathed Thermocouple Material for Test*:

8.1.1 *Bulk Material Length*—Complete the procedures described in 8.1.1.1, 8.1.1.2, and 8.1.1.3 within 1 min and perform in a location where the moisture content of the ambient atmosphere (air) does not exceed the equivalent of 50 % relative humidity at 22°C.

8.1.1.1 Remove the seal and a 5 to 30 mm length of the metal sheath from one end of the bulk material length. Use of a metal-sheathed cable stripper (commercially available) is recommended for removing the sheath.

NOTE 2—Other sheath removal methods will be permitted provided a clean sheath removal is made, one that does not contaminate the insulation nor reduce the effective cross-sectional insulation spacing dimensions.

8.1.1.2 Remove the exposed compacted ceramic insulation surrounding the thermoelements.

8.1.1.3 Separate (or spread apart) the thermoelements so that they are not in contact with each other or with the sheath.

8.1.1.4 Immediately after completing the procedure described in 8.1.1.3, heat the open end of the sheathed thermocouple material with a heat source to remove moisture introduced while performing the procedures in 8.1.1.1-8.1.1.3. Starting approximately 75 mm from the open end and proceeding towards it, move the heat source slowly along the sheath. Repeat this process until the entire 75 mm end portion attains a temperature of approximately 200 to 300°C.

NOTE 3—Magnesium oxide insulation is extremely hygroscopic. Moisture absorption from the ambient atmosphere may degrade the insulation resistance by several orders of magnitude, or more, with exposure for only a few minutes.

8.1.1.5 Seal the open end of the bulk material length immediately, before it cools appreciably, by applying a sealant of epoxy resin. Make sure the epoxy resin sealant completely covers the end of the sheathed thermocouple material and extends at least 3 mm along the outside of the sheath from the end but keep the tips of the bare thermoelements free of epoxy resin.

8.1.1.6 Heat the applied epoxy resin with hot air (at approximately 200°C) to accelerate its curing process. Then, allow the end seal to cool slowly to room temperature. Do not handle the end seal with bare hands. Keep the seal clean and dry.

8.1.1.7 Remove the environmental seal at the other end of

[3] Devcon "5-Minute" Epoxy, (Devcon Corp., Endicott St. Danvers, MA 01923), or an equivalent nonconducting epoxy, has been found suitable for this purpose.

the bulk material length and immediately prepare the end by following the procedures described in 8.1.1-8.1.1.6.

8.1.1.8 Allow the seals at both ends of the bulk material length to cure completely. Inspect the seals for defects using an optical magnifier that has a magnification of 5× to 10×. If any cracks, air pockets, or voids are observed, consider the seal defective. Remove the defective seal and a 100 to 125 mm length of metal sheath adjacent to it, and prepare a new seal by repeating the procedures in 8.1.1-8.1.1.6.

8.1.2 *Test Specimen*—Cut the test specimen from the bulk material length by using diagonal cutters, a tube cutter, or a metal saw, and seal the cut end of the bulk material length following the procedures described in 8.1.1-8.1.1.6.

8.1.2.1 Prepare both ends of the test specimen following the procedures described in 8.1.1-8.1.1.3.

8.1.2.2 Perform the procedures in 8.1.2.1 in accordance with the requirements given in 8.1.1.

8.1.2.3 Heat both ends of the test specimen with a heat source to remove moisture introduced while performing the above procedures. Follow the procedure described in 8.1.1.4 for heating the ends of the test specimen.

8.1.2.4 Seal both ends of the test specimen as described in 8.1.1.5 and 8.1.1.6.

8.1.2.5 Inspect seals for defects as described in 8.1.1.8. If any defect is observed in the seals, discard the test specimen and prepare a new one by repeating the procedures in 8.1.2.1-8.1.2.4.

8.2 *Resistance Measurement*:

8.2.1 Make the resistance measurements of the bulk material length or test specimen after the epoxy resin sealant has cured but not later than 72 h after sealing. Make the resistance measurements in a dry location and where the temperature is between 17 and 27°C.

NOTE 4—Surface adsorption of atmospheric moisture on the end seals will be a problem in conducting the test, and care must be taken to ensure that the end seals of the test specimen are clean and dry when tests are made.

8.2.2 Make electrical connections to any two thermoelements from the input terminals of the resistance measuring instrument.

8.2.2.1 When insulated copper connecting wires are used for this purpose, make sure the open-circuit resistance between them is greater than $1 \times 10^{13}\Omega$.

NOTE 5—Large errors can arise in the measurement of high resistances due to electrical current leakage effects. Electrical resistance measurement techniques for high resistance should be used to minimize current leakage.

8.2.3 Adjust the resistance measuring instrument for an applied voltage of either 50 ± 2 V d-c or 500 ± 20 V d-c. Use a test voltage of 500 V d-c when the outside diameter of the sheathed thermocouple material is greater than 1.5 mm. Use of 50 V d-c is recommended for smaller diameter materials.

8.2.4 Record the time and energize the measuring circuit.

8.2.5 Select the lowest range of the measuring instrument that gives an on-scale reading.

8.2.6 After 1 min from the time recorded in 8.2.4, record the reading indicated by the measuring instrument.

8.2.7 Reverse the polarity of the applied voltage and repeat 8.2.4-8.2.6.

8.2.7.1 Interchange the positions of the connecting wires at either the measuring instrument or the thermoelements to accomplish the polarity reversal.

8.2.8 Make electrical connections to one of the thermoelements and to the sheath from the input terminals of the resistance measuring instrument.

8.2.9 Follow procedures given in 8.2.3-8.2.7 for the resistance measurements.

8.2.10 Make electrical connections to the other thermoelement and the sheath as in 8.2.8 and follow procedures given in 8.2.3-8.2.7 for the resistance measurements.

8.2.11 Repeat the procedures described in 8.2.2-8.2.9 for each thermoelement contained in the bulk material length or test specimen.

9. Report

9.1 Report the following information:

9.1.1 Date and time of the test,

9.1.2 Identification of the bulk material length and test specimen (if taken) including its nominal dimensions (length and outside diameter), the type of sheath, insulation, and the number and type of thermoelements,

9.1.3 Brief description of the resistance measuring instrument used, including its accuracy,

9.1.4 The applied voltage used for the resistance measurements,

9.1.5 Values of the resistances measured between each thermoelement and between each thermoelement and the sheath, for both normal and reversed polarity, and

9.1.6 Ambient temperature and relative humidity during test period.

10. Precision and Bias

10.1 Insulation resistance is primarily used as an in-process check on insulation quality and cleanliness. Measurements of resistance are not usually repeated or reproduced. Consequently, statements of precision and bias are not relevant. When an insulation resistance test at room temperature is prescribed as a purchasing stipulation, both parties should concur as to the details of the test, and should be aware that disagreement by an order of magnitude is not unusual.

11. Keywords

11.1 insulation resistance; sheathed thermocouple insulation resistance; sheathed thermocouple material insulation resistance