



Standard Test Method for Thermal EMF Test of Single Thermoelement Materials by Comparison with a Reference Thermoelement of Similar EMF-Temperature Properties¹

This standard is issued under the fixed designation E207; 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.

^{ε1} NOTE—Editorial changes were made throughout in June 2015.

1. Scope

1.1 This test method covers a test for determining the thermoelectric emf of a thermoelement versus NIST platinum 67 (Pt-67) by means of measuring the difference between the emf of the test thermoelement and the emf of a reference thermoelement (previously referred to as a secondary standard), which has a known relationship to NIST Pt-67.

1.2 This test is applicable to new thermocouple materials over the temperature ranges normally associated with thermocouples and their extension wires. The table on Suggested Upper Temperature Limits for Protected Thermocouples in Specification E230 lists the ranges associated with the letter-designated types of thermocouples. *ASTM MNL-12*² lists the temperature range of extension circuit materials.

1.3 This test is not applicable to stability testing or inhomogeneity testing.

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

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:³

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 *Manual on the Use of Thermocouples in Temperature Measurement*, ASTM MNL-12, Fourth Edition, ASTM, April 1993. (Revision of STP 407B).

³ 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.

E77 Test Method for Inspection and Verification of Thermometers

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

E230 Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples

E344 Terminology Relating to Thermometry and Hydrometry

E563 Practice for Preparation and Use of an Ice-Point Bath as a Reference Temperature

3. Terminology

3.1 *Definitions*—The terms used in this test method are defined in Terminology E344.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *reference facility, n*—NIST, or a testing laboratory whose physical standards are traceable to NIST or another national standards laboratory.

3.2.2 *test temperature, n*—the temperature of the measuring junction.

3.2.2.1 *Discussion*—In reporting the results, the value of the test temperature may be rounded off, provided the stated test temperature is within the bounds indicated in 10.10.

4. Summary of Test Method

4.1 The emf of a thermoelement sample is determined by comparison to a reference thermoelement that has similar Seebeck coefficients.

4.2 This test is conducted on one or more lengths of specimens connected to a single length of the reference thermoelement at a single point. The joined ends are held at the test temperature, and their opposite ends are held at a constant reference temperature.

4.3 The emf of the reference thermoelement relative to Pt-67 at several test temperatures are provided by a reference facility.

4.4 The emf of the test thermoelement relative to Pt-67 is determined by algebraically adding the measured emf to the emf of the reference thermoelement at each test temperature.

5. Significance and Use

5.1 This test method is designed to calibrate a thermoelement at one or more test temperatures. The data obtained are sometimes referred to as initial values of emf because the time at the test temperature is limited.

5.2 This test method is employed mainly by providers of spools or coils of wire or strips of thermoelectric material. Generally more than one specimen at a time is tested, and the resultant emfs of individual thermoelements are used to match to companion thermoelements for use as thermocouples or in extension wiring.

5.3 The emf of a thermocouple comprised of two different thermoelements as tested with this test method may be determined by algebraically subtracting the emf of the negative thermoelement from the emf of the positive thermoelement at a particular temperature. The emf of a thermocouple may also be determined by the test described in Test Method E220, but Test Method E220 does not take into account the values of the emf of the individual thermoelements relative to Pt-67.

5.4 This test method is normally used for the calibration of thermocouple materials during their production or distribution, not for the accurate determination of the properties of a used thermocouple. If the test samples were subjected to previous use, the test results may not reflect the same emf as the thermocouple did while in service. For example, inhomogeneities may have been induced in the wires because of a chemical or metallurgical reaction while in service. Since emf is developed in the thermal gradient, and it is unlikely that the temperature profile along the wire under testing conditions will be the same as it was while in service, the test results may be misleading.

5.5 The test results are suitable for specification acceptance, manufacturing control, design, or research and development purposes.

6. Test Specimen

6.1 Each sample shall represent one continuous spool, coil, or strip of thermoelectric material. The sample shall consist of two specimens, one cut from each end of the spool, coil, or strip. The extreme ends shall not be acceptable if they are distorted or have been subjected to processing dissimilar to the bulk of the spool, coil, or strip.

6.2 Insulation or covering shall be removed with care if it interferes with the test. Straining the test specimen shall be avoided.

6.3 The specimens shall be cleaned of any extraneous surface contamination.

6.4 The specimens and the reference thermoelement shall be long enough to extend continuously from the measuring junction to the reference junction. A length of 600 to 1200 mm (2 to 4 ft) is generally satisfactory. The exact length depends upon the depth of immersion in the testing medium and the

transverse size (for example, diameter of round wire, width of strip) of the thermoelement.

6.4.1 Heating of the measuring junctions shall not affect the temperature of the reference junctions during the period of test.

7. Reference Thermoelement

7.1 The reference thermoelement has its emf established relative to NIST Pt-67 over the temperature range of its intended use. A specific lot of thermoelement material is usually reserved for use as reference thermoelements.

7.2 The emf of the reference thermoelement versus platinum (Pt-67) shall conform to Specification E230 within one half the standard tolerance specified for the related thermocouple type. For example, the tolerance for KP versus Pt-67 is $\pm 1^\circ\text{C}$ or $\pm 0.375\%$ of temperature from 0 to 1260°C , whichever is greater.

7.3 The cross section of the base metal thermoelement shall be sufficiently large so that oxidation caused by the temperatures of testing would not significantly affect its emf over the period of the test.

7.4 To provide some assurance that the reserved lot is uniform in emf from end to end, it shall be manufactured in one continuous length with no in-process welds. Cold working of the material after the final anneal shall be minimized.

7.4.1 A specimen from each end of the reserved lot shall be tested using this test method. The test temperatures shall include the extremes of the intended range of use and additional test points that are no more than 260°C (500°F) apart.

7.4.2 The emf difference between the specimens of 7.4.1 at each test temperature shall not exceed the equivalent of 0.33°C (0.6°F) for that thermocouple type or 0.05 % of the value of the test temperature in degrees Celsius, whichever is the greater.

7.5 From the lot that meets the stated uniformity requirements, at least one unused 1 m (3-ft) section shall be certified by a reference facility to document its emf relative to Pt-67. Traceability shall be required in the form of a certificate issued by the reference facility.

7.5.1 Emf data shall be provided every 50°C (100°F) or at intervals that do not exceed 25 % of the test temperature range, whichever is the lesser. If fewer than the aforementioned number of points are taken, then the data are applicable only at or near the measured temperatures, and interpolation beyond them should not be attempted.

7.5.2 The emf of the reference thermoelement at intermediate values of temperature may be determined by one of the following methods.

7.5.2.1 For the letter-designated thermocouple types, emf functions for thermoelements versus Pt-67 are given in Specification E230. In these cases, the deviation of the reference thermoelement emf from the function value is first calculated at the test temperatures. At an intermediate temperature, the deviation of emf is calculated either by linear interpolation or by fitting a polynomial to the deviation of emf using the method of least squares, and evaluating the polynomial at the intermediate temperature. For the least squares method, the number of data points shall equal or exceed twice the number of parameters fitted. Addition of the deviation of emf to the