Designation: E644 – 11 (Reapproved 2025)

Standard Test Methods for Testing Industrial Resistance Thermometers[1]

This standard is issued under the fixed designation E644; 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 These test methods cover the principles, apparatus, and procedures for calibration and testing of industrial resistance thermometers.

1.2 These test methods cover the tests for insulation resistance, calibration, immersion error, pressure effects, thermal response time, vibration effect, mechanical shock, self-heating effect, stability, thermoelectric effect, humidity, thermal hysteresis, thermal shock, and end seal integrity.

1.3 These test methods are not necessarily intended for, recommended to be performed on, or appropriate for every type of thermometer. The expected repeatability and reproducibility of the results are tabulated in Appendix X4.

1.4 These test methods, when specified in a procurement document, shall govern the method of testing the resistance thermometer.

1.5 Thermometer performance specifications, acceptance limits, and sampling methods are not covered in these test methods; they should be specified separately in the procurement document.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in 5, 6, 8, 16, and 17.

1.7 *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]

E1 Specification for ASTM Liquid-in-Glass Thermometers

E77 Test Method for Inspection and Verification of Thermometers

E230/E230M Specification for 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

E1137/E1137M Specification for Industrial Platinum Resistance Thermometers

E1502 Guide for Use of Fixed-Point Cells for Reference Temperatures

E1750 Guide for Use of Water Triple Point Cells

E1751/E1751M Guide for Temperature Electromotive Force (emf) Tables for Non-Letter Designated Thermocouple Combinations

E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids

2.2 *Military Standard:*[3]

MIL-STD-202 Test Methods for Electronic and Electrical Component Parts

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 The definitions given in Terminology E344 shall apply to these test methods.

3.1.2 *bath gradient error, n*—the error caused by temperature differences in the working space of the bath. (The bath or temperature equalizing blocks should be explored to determine the work areas in which the temperature gradients are insignificant.)

3.1.3 *connecting wire error, n*—the error caused by uncompensated connecting wire resistance. (Although the connecting wire is part of the measurement circuit, most of it is not at the

[1] These test methods are under the jurisdiction of ASTM Committee E20 on Temperature Measurement and are the direct responsibility of Subcommittee E20.03 on Resistance Thermometers.

Current edition approved Jan. 1, 2025. Published January 2025. Originally approved in 1978. Last previous edition approved in 2019 as E644 – 11 (2019). DOI: 10.1520/E0644-11R25.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20234.

temperature that is being determined. Thermometers are available in two-, three-, and four-wire configurations. There is no satisfactory way to compensate for the wire resistance in the measurement with a two-wire thermometer although the wire resistance can be compensated for in three and four-wire thermometers.)

3.1.4 *immersion error, n*—an error caused by the heat conduction or radiation, or both, between the resistance thermometer element and the environment external to the measurement system, because of insufficient immersion length and thermal contact of the thermometer with the medium under measurement.

3.1.5 *interchangeability, n*—the extent to which the thermometer matches a resistance-temperature relationship. (The verification of interchangeability can be accomplished only by calibration. The deviations at the temperature limits and the maximum deviation from the established resistance-temperature relationship shall be specified.)

3.1.6 *self-heating, n*—the increase in the temperature of the thermometer element caused by the electric power dissipated in the element, the magnitude depending upon the thermometer current and heat conduction from the thermometer element to the surrounding medium.

3.1.7 *self-heating error, n*—the error caused by variations from the calibration conditions in the self-heating of the thermometer element at a given current, arising from the variations in the heat conduction from the thermometer to the surrounding medium.

3.1.8 *thermoelectric effect error, n*—the error caused by a thermal emf in the measurement circuit as a result of dissimilar metals and temperature gradients in the circuit.

4. Significance and Use

4.1 These test methods provide uniform methods for testing industrial resistance thermometers so that a given tester may expect to obtain the same value of a test result from making successive measurements on the same test article within the limits of repeatability given in Appendix X4. Independent testers may also expect to obtain the same result from the testing of the same article within the limits of reproducibility given in Appendix X4.

4.2 These tests may be used to qualify platinum resistance thermometers for use in specific applications to meet a particular specification such as Specification E1137/E1137M, or to evaluate relative merits of equivalent test articles supplied by one or more manufacturers, or to determine the limits of the application of a particular design of thermometer.

4.3 The expected repeatability and reproducibility of selected test methods are included in Appendix X4.

4.4 Some non-destructive tests described in these test methods may be applied to thermometers that can be subsequently sold or used; other destructive tests may preclude the sale or use of the test article because of damage that the test may produce.

PROCEDURES

5. Insulation Resistance Test

5.1 *Scope*—The insulation resistance between the thermometer element with its connecting wires and its external shield, case or means for mounting, should be sufficient to prevent significant electrical shunting or ground loop current in the measurement circuit, or any circuit failure if the excitation source is grounded. This test assumes that the thermometer has a metallic or other electrically conductive sheath or housing. The most probable factors that contribute to insulation failure are contamination, typically from moisture, and mechanical breakdown due to physical damage to the device. Most ceramic oxide insulation absorbs moisture. This moisture is expected to migrate inside the thermometer, depending upon the temperature condition of use, and to cause variations in the insulation resistance. Test conditions for insulation resistance should therefore approximate the most severe conditions of probable use and shall be specified as a minimum at a specific temperature, humidity, pressure and test voltage. It is recommended that insulation resistance be measured using forward and reversed polarity on applied dc voltages. The test methods customarily applied with the test article at room temperature may also be employed to determine the insulation resistance at temperatures up to the rated application temperature for the resistance thermometer. This is intended to be a non-destructive test.

5.1.1 The insulation resistance, as measured between the lead wires and case, does not represent the shunt resistance in parallel with the sensing element. Therefore, this test should not be used to estimate temperature measurement errors caused by inadequate insulation resistance across the sensing element.

5.2 *Apparatus:*

5.2.1 Because the insulation resistance is to be measured in conjunction with other tests, the thermometer shall be mounted as required for these tests.

5.2.2 Any equipment made for the purpose of insulation resistance testing shall be capable of measuring a resistance of at least 10 gigohms ($10^{10}\Omega$) at the specified test voltage. (**Warning—**Some instruments designed for insulation resistance testing are capable of producing lethal voltages (100 V or greater) at their measuring terminals. Such instruments should have warning labels and used only by supervised and well trained personnel.)

5.3 *Measurement Procedure:*

5.3.1 Make check measurements on a reference resistor of 10 gigohms (10^{10} Ω). Check the measurement instrument to ±5 % at the required minimum insulation resistance using a certified reference resistor. These results should accompany the test report on the platinum resistance thermometer (PRT). For example: When testing a PRT with a specified 100 megohm (10^{8} Ω) minimum insulation resistance, the meter should be tested with a resistor that has a certified resistance of 100 megohms ±5 %.

5.3.2 Make insulation resistance measurements between the connecting wires and the shield or case, (*1*) before the thermometer is subjected to the conditions of any concurrent test (calibration, pressure, vibration), (*2*) during the test, and