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Standard Guide for Accuracy Verification of Industrial Platinum Resistance Thermometers[1]

This standard is issued under the fixed designation E2593; 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 guide describes the techniques and apparatus required for the accuracy verification of industrial platinum resistance thermometers constructed in accordance with Specification E1137/E1137M and the evaluation of calibration uncertainties. The procedures described apply over the range of -200 °C to 650 °C.

1.2 This guide does not intend to describe procedures necessary for the calibration of platinum resistance thermometers used as calibration standards or Standard Platinum Resistance Thermometers. Consequently, calibration of these types of instruments is outside the scope of this guide.

1.3 Industrial platinum resistance thermometers are available in many styles and configurations. This guide does not purport to determine the suitability of any particular design, style, or configuration for calibration over a desired temperature range.

1.4 The evaluation of uncertainties is based upon current international practices as described in JCGM 100:2008 "Evaluation of measurement data—Guide to the expression of uncertainty in measurement" and ANSI/NCSL Z540.2-1997 "U.S. Guide to the Expression of Uncertainty in Measurement."

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

E344 Terminology Relating to Thermometry and Hydrometry

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

E644 Test Methods for Testing Industrial Resistance Thermometers

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

E2623 Practice for Reporting Thermometer Calibrations

E2488 Guide for the Preparation and Evaluation of Liquid Baths Used for Temperature Calibration by Comparison

2.2 *ANSI Publications:*[3]

ANSI/NCSL Z540.2-1997 U.S. Guide to the Expression of Uncertainty in Measurement

ANSI/NCSL Z540.3-2006 Requirements for the Calibrations of Measuring and Test Equipment

2.3 *Other Publication:*[4]

JCGM 100:2008 Evaluation of measurement data—Guide to the expression of uncertainty in measurement

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E344 shall be considered as applying to the terms used in this guide.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *annealing, v*—a heat treating process intended to stabilize resistance thermometers prior to calibration and use.

[1] This guide is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.03 on Resistance Thermometers.

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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] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] JCGM 100:2008, Evaluation of measurement data—Guide to the expression of uncertainty in measurement. Available from the BIPM, Sevres, France, http://www.bipm.org/en/publications/guides/gum.html.

3.2.2 *check standard, n*—a thermometer similar in design to the unit under test, but of superior stability, which is included in the calibration process for the purpose of quantifying the process variability.

3.2.3 *coverage factor, n*—numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty.

3.2.4 *dielectric absorption, n*—an effect in an insulator caused by the polarization of positive and negative charges within the insulator which manifests itself as an in-phase current when the voltage is removed and the charges recombine.

3.2.5 *expanded uncertainty, U, n*—quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand.

3.2.5.1 *Discussion*—Typically, *U* is given at a coverage factor of 2, approximating to a 95.45 % confidence interval for a normal distribution.

3.2.6 *hysteresis, n*—property associated with the resistance of a thermometer whereby the value of resistance at a temperature is dependent upon previous exposure to different temperatures.

3.2.7 *normal distribution, n*—a frequency distribution characterized by a bell-shaped curve and defined by two parameters: mean and standard deviation.

3.2.8 *platinum resistance thermometer (PRT), n*—a resistance thermometer with the resistance element constructed from platinum or platinum alloy.

3.2.9 *rectangular distribution, n*—a frequency distribution characterized by a rectangular-shaped curve and defined by two parameters: mean and magnitude (semi-range).

3.2.10 *standard deviation of the mean, n*—an estimate of the standard deviation of the sampling distribution of means, based on the data from one or more random samples.

3.2.10.1 *Discussion*—Numerically, it is equal to the standard deviation obtained (*s*) when divided by the square root of the size of the sample (*n*).

$$\text{Standard Deviation of the Mean} = \frac{s}{\sqrt{n}} \quad (1)$$

3.2.11 *standard platinum resistance thermometer (SPRT), n*—a specialized platinum resistance thermometer constructed in such a way that it fulfills the requirements of the ITS-90.[5]

3.2.12 *standard uncertainty, n*—uncertainty of the result of a measurement expressed as a standard deviation, designated as *S*.

3.2.13 *Type A evaluation (of uncertainty), n*—method of evaluation of uncertainty by the statistical analysis of a series of observations.[4]

3.2.14 *Type B evaluation (of uncertainty), n*—method of evaluation of uncertainty by means other than statistical analysis of a series of observations.[4]

3.2.15 *test uncertainty ratio (TUR), n*—the ratio of the tolerance of the unit under test to the expanded calibration uncertainty.

3.2.16 *uncertainty budget, n*—an analysis tool used for assembling and combining component uncertainties expected in a measurement process into an overall expected uncertainty.

3.2.17 *unit under test (UUT), n*—the platinum resistance thermometer to be calibrated.

4. Summary of Guide

4.1 The UUT is calibrated by determining the electrical resistance of its sensing element at one or more known temperatures covering the temperature range of interest. The known temperatures may be established by means of fixed-point systems or by using a reference thermometer. Either an SPRT or a PRT is recommended for use as the reference thermometer. However, a liquid in glass (LIG) thermometer, thermistor, or thermocouple may be acceptable, depending upon the temperature of calibration, required accuracy, or other considerations.

4.2 The success of the calibration depends largely upon the ability of the UUT to come to thermal equilibrium with the calibration temperature of interest (fixed point cell or comparison system) and upon accurate measurement of the sensing element resistance at that time. Instructions are included to guide the user in achieving thermal equilibrium and proper resistance measurement, including descriptions of apparatus and instrumentation.

4.3 Industrial platinum resistance thermometers are available in many styles and configurations. This guide includes limited instructions pertaining to the preparation of the UUT into a configuration that facilitates proper calibration.

4.4 Proper evaluation of calibration uncertainties is critical for the result of a calibration to be useful. Therefore, a considerable portion of this guide is devoted to uncertainty budgets and the evaluation of uncertainties.

5. Significance and Use

5.1 This guide is intended to be used for verifying the resistance-temperature relationship of industrial platinum resistance thermometers that are intended to satisfy the requirements of Specification E1137/E1137M. It is intended to provide a consistent method for calibration and uncertainty evaluation while still allowing the user some flexibility in the choice of apparatus and instrumentation. It is understood that the limits of uncertainty obtained depend in large part upon the apparatus and instrumentation used. Therefore, since this guide is not prescriptive in approach, it provides detailed instruction in uncertainty evaluation to accommodate the variety of apparatus and instrumentation that may be employed.

5.2 This guide is intended primarily to satisfy applications requiring compliance to Specification E1137/E1137M. However, the techniques described may be appropriate for applications where more accurate calibrations are needed.

[5] Mangum, B. W., NIST Technical Note 1265, Guidelines for Realizing the International Temperature Scale of 1990 (ITS-90).