Designation: E2623 – 14 (Reapproved 2021)

Standard Practice for Reporting Thermometer Calibrations[1]

This standard is issued under the fixed designation E2623; 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 practice contains reporting requirements for thermometer calibrations included in ASTM Committee E20 Test Methods.

1.2 This practice covers reports of calibration for radiation thermometers, liquid-in-glass thermometers, resistance thermometers, digital thermometers, and new thermocouples.

NOTE 1—This practice does not apply to used thermocouples.

1.3 *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.*

1.4 *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]

E77 Test Method for Inspection and Verification of Thermometers

E344 Terminology Relating to Thermometry and Hydrometry

E1137 Specification for Industrial Platinum Resistance Thermometers

2.2 *Other Standards or Guides:*

ANSI/NCSL Z540.3-2006 American National Standard for Calibration—Calibration Laboratories and Measuring and Test Equipment—General Requirements[3]

ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration Laboratories[3]

JCGM100:2008 Evaluation of Measurement Data—Guide to the Expression of Uncertainty in Measurement

ISO/IEC Guide 98-3 Uncertainty of Measurement—Part 3: Guide to the Expression of Uncertainty in Measurement (GUM:1995)

NIST Technical Note 1297 Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, 1994 Edition

UKAS M3003 The Expression of Uncertainty and Confidence in Measurement, Edition 2

ANSI/NCSL Z540.2-1997 (R2002) U.S. Guide to the Expression of Uncertainty in Measurement

3. Terminology

3.1 *Definitions*—Definitions given in Terminology E344, unless otherwise defined herein, apply to terms as used in this practice.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *correction, n*—numerical value added to the uncorrected result of a measurement to compensate for errors.

3.2.1.1 *Discussion*—The correction is equal to the negative of the estimated errors. Since the systematic error cannot be known perfectly, the compensation cannot be complete.

3.2.2 *error, n*—the indication of a thermometer or temperature measuring device minus the true value of the corresponding input quantity.

3.2.2.1 *Discussion*—Since the true value cannot be determined, in practice a conventional true value is used. This concept applies mainly when the instrument is compared to a reference standard.

3.2.3 *gradient zone, n*—the section of a thermocouple that is exposed during a measurement to temperatures in the range from $t_{amb} + 0.1(t_m - t_{amb})$ to $t_{amb} + 0.9(t_m - t_{amb})$, where t_{amb} is ambient temperature and t_m is the temperature of the measuring junction (all in °C).

3.2.3.1 *Discussion*—This term is used in thermocouple calibration reports as part of the description of the thermal profile along the length of the thermocouple. Although thermocouple emf is a function of the measuring and reference junction temperatures, the emf is actually generated along the length of the thermocouple, wherever the thermoelements pass through a

[1] This practice is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.07 on Fundamentals in Thermometry.

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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.

temperature gradient. The gradient zone definition is intended to describe, in an approximate way, the section of thermocouple that created most of the emf during the calibration.

3.2.4 *half-maximum heated length, n*—the distance between the tip of the temperature sensor and the position along the length of the sensor leads or sheath where the temperature equals the average of the calibration-point and ambient temperatures.

3.2.4.1 *Discussion*—This term is used in thermocouple calibration reports as part of the description of the thermal profile along the length of the thermocouple.

4. Summary of Practice

4.1 This practice describes the required information necessary for reporting results of temperature calibrations included in ASTM Test Methods.

5. Significance and Use

5.1 This practice is adequate for use with all ASTM Test Methods which require the reporting of temperature measurements.

5.2 The Report of Calibration, however named, is the physical output of the calibration laboratory. It shall be prepared so that both the results of the measurement(s) and the non-technical information necessary to support those results are conveyed in a manner that ensures accurate communication and justification of the results.

5.3 This practice is not meant to supersede requirements of other standards practice such as ISO/IEC 17025 or ANSI/NCSL Z540.3.

6. Procedure

6.1 *Requirements for Written Report*— The requirements in 6.1.1 through 6.1.14 are mandatory for all written reports issued in compliance with this practice. Subsections 6.1.15 through 6.1.19 include general provisions for information that may be omitted if not required by a calibration procedure or client/user.

6.1.1 *Title Examples*—Report of Calibration, Calibration Certificate, Test Report or Test Certificate.

6.1.2 Name and address of the laboratory and location where the calibration was performed, if different from the laboratory address.

6.1.3 Unique identification of the report or certificate, and on each page an identification in order to ensure that the page is recognized as part of the report or certificate, a clear identification of the end of the report or certificate, and the page number and total number of pages.

6.1.4 Name and address of the client.

6.1.5 Statement and concise description of the test method or calibration procedure used. This statement shall include revisions and the date of the test method or calibration procedure. Test methods can consist of published standards (such as ASTM Test Methods), internally developed methods, or a combination of both.

6.1.5.1 Information describing deviations from previously agreed-upon procedures.

6.1.6 Description of the thermometer or thermocouple, the overall range, and, if different, the calibrated range. This shall also include the manufacturer, model number (as applicable), identification or unique serial number, and the condition of the thermometer or thermocouple upon receipt.

6.1.7 *Date of Calibration:*

6.1.7.1 Where applicable, additional dates, including date received, date of report preparation and next due date may be included.

6.1.8 *Calibration Results*—This can take the form of a table with reading of standard temperature, reading of test instrument, corrections to be applied and consistent units of measure or any form of reporting as requested by the customer.

6.1.8.1 When an instrument has been repaired or adjusted, the calibration results before and after repair or adjustment shall be reported, if available.

6.1.9 Conditions (for example, environmental conditions) under which the calibrations were made that have an influence on the measurement results.

6.1.10 A statement of the estimated uncertainty(ies) of measurement and the corresponding level of confidence.

6.1.10.1 Method for estimating uncertainties. Internationally the BIPM document JCGM100:2008 (“Guide to the Expression of Uncertianty of Measurement”) is cited, ISO/IEC Guide 98-3, NIST Technical Note 1297, UKAS M3003 and Z540.2-1997 (R2002) also meet this requirement.

6.1.10.2 Coverage factor and estimated confidence interval. Typically the coverage factor (k) is 2 for an approximate confidence level of 95%.

6.1.11 Traceability statement to the International System of Units (SI) through the National Institute of Standards and Technology (NIST) or other National Metrological Institute (NMI) of test equipment used in the test or calibration.

6.1.12 Signature or equivalent identification of the responsible party.

6.1.12.1 Other signatures may be required, at the discretion of the laboratory manager. Each signatory or named person accepts responsibility for the contents of the report.

6.1.13 A statement specifying that the calibration certificate, however named, shall not be reproduced except in full, without written approval of the laboratory.

6.1.14 Statement of Temperature Scale (for example, International Temperature Scale of 1990 (ITS-90)).

6.1.15 Where appropriate and needed, opinions and interpretations, including additional information which may be required by specific methods, clients or groups of clients.

6.1.16 Where relevant, a sampling plan and procedure and a statement to the effect that the results relate only to the items calibrated.

6.1.17 Where relevant, a statement of compliance/non-compliance with requirements or specification, or both.

6.1.17.1 Compliance may refer to all criteria, including both specifications and maximum permissible error, of a referenced standard. When the scope of calibration is limited to only certain portions of the standard, the statement of compliance shall cite and be limited to those sections of the referenced

standard with which the thermometer complies. If non-compliance is to be noted, the statement should cite those sections of the referenced standard for which the thermometer fails to comply.

6.1.18 Date of receipt of calibration item where this is critical to the validity and application of the results.

6.1.19 When applicable, customer purchase order or reference number and date.

6.2 *Additional Requirements for All Reported Calibrations for Radiation Thermometers only:*

6.2.1 Statement of source type (blackbody, filament lamp, and so forth).

6.2.2 Statement of source aperture or diameter of flat type sources.

6.2.3 Statement of measuring distances between the objective lens and the source aperture or cavity bottom, or both.

6.2.4 Statement of aperture distance, if an aperture is used.

6.2.5 Statement of field-of-view or size of source (as referenced to the thermometer under test).

6.2.6 Statement of emissivity of the thermometer under test (emissivity setting of the thermometer under test).

6.2.7 Statement of source emissivity.

6.2.8 Statement of the spectral response of the thermometer under test.

6.2.9 Statement of traceability of the source through contact or radiation thermometry.

6.3 *Additional Requirements for All Reported Calibrations of Liquid-in-Glass Thermometers:*

6.3.1 Statement of minimum length of time at test temperature before reading.

NOTE 2—The time allowed for equilibrium of a liquid-in-glass thermometer is dependent on the type of thermometric liquid used. For the purposes of this practice, the timing device for this measurement does not need to be traceable to an National Metrology Institute (NMI).

6.3.2 Statement of emergent stem temperature either in chart or text form (for partial immersion thermometers or total immersion thermometers calibrated with partial immersion only).

6.4 *Additional Requirements for Reported Calibrations of Resistance Thermometers*—The requirements in 6.4.1 – 6.4.4 are mandatory for all written reports for resistance thermometers issued in compliance with this practice. Subsections 6.4.5 – 6.4.9 include general provisions for information that may be omitted if not required by a calibration procedure or client/user.

6.4.1 As found values R(0.01 °C), R(0 °C) or other agreed-upon value.

6.4.2 Change in R(0.01 °C) or R(0 °C) observed during calibration.

6.4.3 Nominal excitation current.

6.4.4 Uncertainty of fitted results, if different from the uncertainty of measurement data.

6.4.5 Tabulated resisteance, $R(t)$ when specified by the client/user.

6.4.6 Hysteresis results, if applicable.

6.4.7 Fitting equation or reference to fitting equation, if applicable.

6.4.8 Fitting residuals, if applicable.

6.4.9 Repeatability results, if applicable.

6.5 *Additional Requirements for Reported Calibrations of Thermocouples*—The requirements in 6.5.1 and 6.5.2 are mandatory for all written reports for thermocouples issued in compliance with this practice. Subsections 6.5.3 – 6.5.6 include general provisions for information that may be omitted if not required by a calibration procedure or the client/user.

6.5.1 Mathematical description of any fitting equation used in reporting the results of the calibration. The equation may consist of a deviation function modeling the difference in emf from a reference function of a stated thermocouple type, or the equation may consist of a function giving emf-versus-measuring junction temperature.

6.5.2 Statement whether any allowance is included in the uncertainty for thermocouple drift and inhomogeneity.

6.5.3 Immersion depth used during the test.

6.5.4 Gradient zone of the thermocouple during the test.

6.5.5 Statement of calibration set up, if applicable.

6.5.6 Reference junction temperature.

6.6 *Additional Requirements for Reported Calibrations of Digital Thermometers*—The requirements in 6.6.1 – 6.6.3 are mandatory for all written reports for digital thermometers issued in compliance with this practice. Subsections 6.6.4 – 6.6.6 include general provisions for information that may be omitted if not required by a calibration procedure or the client/user.

6.6.1 For digital thermometers with multiple probes or multiple channels, or both, the report shall identify each thermometer probe calibrated and each corresponding channel used for the calibration.

6.6.2 For digital thermometers that include one or more algorithms for temperature conversion, the report shall include a method of conversion statement, identifying the method(s), all relevant standards, and identify coefficients (if applicable) used for each thermometer channel and probe calibrated.

6.6.3 Where a digital thermometer is checked without a thermometer probe using either resistance or voltage simulation, each sensor type or curve, or both, shall be reported.

6.6.3.1 *Discussion Example*—A common digital thermometer, having two inputs with the capability to read both Type J and K thermocouples, is first calibrated using mV simulation. Secondly, two thermocouple probes, one each Type J and Type K, are calibrated with this unit as a system after verification and adjustment of individual probe ice point offsets on the digital thermometer front panel.

6.6.4 Repeatability results, if applicable.

6.6.5 Reference junction temperature, if applicable (thermocouple probes only).

6.6.6 Statement regarding the recommended upper temperature limit for the probes(s) calibrated (if known).