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Terminology Relating to Thermometry and Hydrometry[1]

This standard is issued under the fixed designation E344; 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 terminology is a compilation of definitions of terms used by ASTM Committee E20 on Temperature Measurement.

1.2 Terms with definitions generally applicable to the fields of thermometry and hydrometry are listed in 3.1.

1.3 Terms with definitions applicable only to the indicated standards in which they appear are listed in 3.2.

1.4 Information about the International Temperature Scale of 1990 is given in Appendix X1.

1.5 *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

E100 Specification for ASTM Hydrometers

E126 Test Method for Inspection, Calibration, and Verification of ASTM Hydrometers

E207 Test Method for Thermal EMF Test of Single Thermoelement Materials by Comparison With Reference Thermoelement of Similar EMF-Temperature Properties

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

E230/E230M Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

E452 Test Method for Calibration of Refractory Metal Thermocouples Using a Radiation Thermometer

E574 Specification for Duplex, Base Metal Thermocouple Wire With Glass Fiber or Silica Fiber Insulation

E585/E585M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Base Metal Thermocouple Cable

E601 Guide for Measuring Electromotive Force (EMF) Stability of Base-Metal Thermoelement Materials With Time in Air

E608/E608M Specification for Mineral-Insulated, Metal-Sheathed Base Metal Thermocouples

E644 Test Methods for Testing Industrial Resistance Thermometers

E667 Specification for Mercury-in-Glass, Maximum Self-Registering Clinical Thermometers (Withdrawn 2022)[3]

E696 Specification for Tungsten-Rhenium Alloy Thermocouple Wire

E710 Test Method for Comparing EMF Stabilities of Base-Metal Thermoelements in Air Using Dual, Simultaneous, Thermal-EMF Indicators (Withdrawn 2006)[3]

E780 Test Method for Measuring the Insulation Resistance of Mineral-Insulated, Metal-Sheathed Thermocouples and Mineral-Insulated, Metal-Sheathed Cable at Room Temperature

E825 Specification for Phase Change-Type Disposable Fever Thermometer for Intermittent Determination of Human Temperature

E839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Cable

E879 Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements

E1061 Specification for Direct-Reading Liquid Crystal Forehead Thermometers

E1104 Specification for Clinical Thermometer Probe Covers and Sheaths

E1112 Specification for Electronic Thermometer for Intermittent Determination of Patient Temperature

E1129/E1129M Specification for Thermocouple Connectors

E1137/E1137M Specification for Industrial Platinum Resistance Thermometers

E1159 Specification for Thermocouple Materials, Platinum-Rhodium Alloys, and Platinum

[1] This terminology is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.91 on Editorial and Terminology.

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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] The last approved version of this historical standard is referenced on www.astm.org.

E1256 Test Methods for Radiation Thermometers (Single Waveband Type)
E1299 Specification for Reusable Phase-Change-Type Fever Thermometer for Intermittent Determination of Human Temperature
E1350 Guide for Testing Sheathed Thermocouples, Thermocouple Assemblies, and Connecting Wires Prior to, and After Installation or Service
E1502 Guide for Use of Fixed-Point Cells for Reference Temperatures
E1594 Guide for Expression of Temperature
E1684/E1684M Specification for Miniature Thermocouple Connectors
E1750 Guide for Use of Water Triple Point Cells
E1751/E1751M Guide for Temperature Electromotive Force (emf) Tables for Non-Letter Designated Thermocouple Combinations
E1965 Specification for Infrared Thermometers for Intermittent Determination of Patient Temperature
E2181/E2181M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Noble Metal Thermocouples and Thermocouple Cable
E2251 Specification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids
E2488 Guide for the Preparation and Evaluation of Liquid Baths Used for Temperature Calibration by Comparison
E2593 Guide for Accuracy Verification of Industrial Platinum Resistance Thermometers
E2623 Practice for Reporting Thermometer Calibrations
E2730 Guide for Calibration and Use of Thermocouple Reference Junction Probes in Evaluation of Electronic Reference Junction Compensation Circuits
E2758 Guide for Selection and Use of Infrared Thermometers
E2820 Test Method for Evaluating Thermal EMF Properties of Base-Metal Thermocouple Connectors
E2821 Specification for Compacted Mineral-Insulated, Metal-Sheathed Cable Used in Industrial Resistance Thermometers
E2846 Guide for Thermocouple Verification
E2847 Test Method for Calibration and Accuracy Verification of Wideband Infrared Thermometers
E2877 Guide for Digital Contact Thermometers
E2995 Specification for ASTM Thermohydrometers with Integral Low-Hazard Thermometers
E3186 Guide for Use and Testing of Dry-Block Temperature Calibrators

2.2 *Other Standards, Supplementary Vocabularies, and Sources:*

2.2.1 *NIST Documents*[4]

ITS-90 The International Temperature Scale of 1990[5]
NIST Monograph 126 Platinum Resistance Thermometry
NIST Monograph 150 Liquid-in-Glass Thermometry
NIST Monograph 175 Temperature-Electromotive Force Reference Functions and Tables for the Letter-Designated Thermocouple Types Based on the ITS-90
NIST SP 250-22 Platinum Resistance Thermometer Calibrations
NIST SP 250-23 Liquid-in-Glass Thermometer Calibration Service
NIST Technical Note 1297 Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, 1994 Edition

2.2.2 *ANSI Documents*[6]

ANSI/NCSL Z540.2-1997 (R2012) U.S. Guide to the Expression of Uncertainty in Measurement
ANSI/NCSL Z540.3-2006 American National Standard for Calibration—Calibration Laboratories and Measuring and Test Equipment—General Requirements

2.2.3 *IEC Documents*[7]

IEC 61298-1 Process Measurement and Control Devices—General Methods and Procedures for Evaluating Performance—Part 1: General Considerations
IEC TS 62492-1 Industrial Process Control Devices—Radiation Thermometers—Part 1: Technical Data for Radiation Thermometers

2.2.4 *BIPM Documents*[8]

JCGM 100:2008 Evaluation of measurement data—Guide to the expression of uncertainty in measurement
JCGM 200:2012 International Vocabulary of Metrology—Basic and General Concepts and Associated Terms (VIM)

2.2.5 *ISO Documents*[9]

ISO/IEC 17025:2017 General Requirements for the Competence of Testing and Calibration Laboratories
ISO/IEC Guide 98-3 Uncertainty of Measurement—Part 3: Guide to the Expression of Uncertainty in Measurement (GUM:1995)
ISO 1768:1975 Glass Hydrometers—Conventional Value for the Thermal Cubic Expansion Coefficient (for Use in the Preparation of Measurement Tables for Liquids)

2.2.6 *Other documents*

UKAS M3003 The Expression of Uncertainty and Confidence in Measurement, Edition 4[10]

3. Terminology

3.1 *Definitions:*

accuracy, *n—of a temperature measurement*, closeness of agreement between the result of a temperature measurement and a true value of the temperature.

DISCUSSION—Accuracy is a qualitative concept.

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

[5] Preston-Thomas, H., METROLOGIA, Vol. 27, 1990, pp 3-10 and 107 (errata). Mangum, B. W., *JOURNAL OF RESEARCH*, National Institute of Standards and Technology, Vol 95, 1990, p. 69.

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

[7] Available from International Electrotechnical Commission (IEC), 3, rue de Varembé, 1st floor, P.O. Box 131, CH-1211, Geneva 20, Switzerland, https://www.iec.ch.

[8] Available from International Bureau of Weights and Measures (BIPM), Pavillon de Breteuil, F-92312 Sèvres Cedex, Paris, France, http://www.bipm.org.

[9] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

[10] United Kingdom Accreditation Service 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, https://www.ukas.com.

base metal thermocouple, *n*—thermocouple whose thermoelements are composed primarily of base metals and their alloys. (See also **noble metal thermocouple; refractory metal; thermocouple**.)

DISCUSSION—Base metals used in thermoelements include nickel, iron, chromium, copper, and aluminum. Letter-designated types E, J, K, T, and N are considered base metal thermocouples.

bias, *n*—the scatter between the mean values of subsets of data, from each other or from the accepted value.

blackbody, *n*—the perfect or ideal source of thermal radiant power having a spectral distribution described by the Planck equation.

DISCUSSION—The term blackbody is often used to describe a furnace or other source of radiant power which approximates the ideal.

bulb, *n—of a liquid-in-glass thermometer*, reservoir for the thermometric liquid.

calibration, *n—of a thermometer or thermometric system*, the set of operations that establishes the relationship between the indications of a thermometer or thermometric system and the corresponding reference standard at discrete temperature values; the operations are performed under specified conditions; the calibration results are often used to establish this relationship at other temperature values; the communicated results shall include a statement of the measurement uncertainty for each measurement result.

DISCUSSION—(1) The result of a calibration permits either the assignment of values of temperature to indicated values of thermometric quantity, or the determination of additive or multiplicative corrections with respect to indications, or both. (2) A calibration may also determine other metrological properties such as the effect of influence quantities. (3) The result of a calibration may be communicated in a document such as a calibration certificate, calibration report, calibration function, calibration diagram, calibration curve, or calibration table. (4) The term calibration has also been used in standards under E20 jurisdiction to refer to the result of the operations, to representations of the result, and to the actual relationship between values of the thermometric quantity and temperature.

calibration point, *n*—a specific value, established by a reference, at which the indication or output of a measuring device is determined.

Celsius, *adj*—pertaining to or denoting something related to the expression of temperature in degrees Celsius.

DISCUSSION—For example, "A **Celsius** thermometer has a scale marked in degrees Celsius."

center wavelength, *n*—a wavelength, usually near the middle of the band of radiant power over which a radiation thermometer responds, that is used to characterize its performance.

DISCUSSION—The value of the center wavelength is usually specified by the manufacturer of the instrument.

clinical thermometer, *n*—thermometer of any type designed to measure human body temperature.

DISCUSSION—Some clinical thermometers may be designed to measure the body temperature of animals.

coaxial thermocouple, *n*—a thermocouple consisting of a thermoelement in wire form within a thermoelement in tube form with the wire being electrically insulated from the tube except at the measuring junction.

compensating extension wires, *n*—those extension wires fabricated from materials basically different in composition from the thermocouple.

DISCUSSION—They have similar thermoelectric properties and within a stated temperature range effectively transfer the reference junction to the other end of the wires.

complete immersion thermometer, *n*—a liquid-in-glass thermometer designed to indicate temperatures correctly when the entire thermometer is exposed to the temperature being measured. (Compare **total immersion thermometer** and **partial immersion thermometer**.)

connection head, *n*—a housing enclosing a terminal block for an electrical temperature-sensing device and usually provided with threaded openings for attachment to a protecting tube and for attachment of conduit.

defining fixed point, *n*—thermometric fixed point of an idealized system, to which a numerical value has been assigned, used in defining a temperature scale.

degree Celsius, °C, *n*—derived unit of temperature in the International System of Units (SI). (See **kelvin**.)

DISCUSSION—At any temperature, an interval of one degree Celsius is the same as an interval of one kelvin, by definition. (For information about the relation between units and values of temperature expressed in different units, see Guide E1594.)

degree centigrade, *n*—obsolete term; use **degree Celsius.**

degree Fahrenheit, °F, *n*—non-SI unit of temperature commonly used in the United States of America.

DISCUSSION—At any temperature, an interval of one degree Fahrenheit is the same as an interval of 5/9 kelvin (or 5/9 degree Celsius). (For information about the relation between units and values of temperature expressed in different units, see Guide E1594.)

electromotive force (emf), *n*—the electrical potential difference which produces or tends to produce an electric current.

error, *n—of a temperature measurement*, result of a temperature measurement minus a true value of temperature.

extension wires, *n*—those having temperature-emf characteristics that when connected to a thermocouple effectively transfer the reference junction to the other end of the wires. (Compare **compensating extension wires.)**

extrapolation, *n*—the estimation of a value of a measurement beyond the values already measured by the extension of a curve based on the measured values.

Fahrenheit, *adj*—pertaining to or denoting something related to the expression of temperature in degrees Fahrenheit.

DISCUSSION—For example, "A **Fahrenheit** thermometer has a scale marked in degrees Fahrenheit."

fixed point, *n—in thermometry*, reproducible temperature of equilibrium of a system of two or more phases under specified conditions.

freezing point, *n*—fixed point of a single component system in which liquid and solid phases are in equilibrium at a

specified pressure, usually 101 325 Pa, and the system is losing heat slowly. (Compare **melting point**.)

grounded junction, *n*—a measuring junction of a thermocouple assembly that is electrically and physically connected to its sheath. (See also **Style G**.)

Discussion—The term "grounded" has been historically accepted in the field of thermometry to indicate the electrical connectivity of a thermocouple's measuring junction to its sheath; the term does not indicate whether or not the measuring junction is electrically connected to earth or circuit ground.

hysteresis, *n*—the property of a device or instrument whereby it gives different output values in relation to its input values depending upon the directional sequence in which the input values have been applied. **IEC 61298-1**

ice point, *n*—thermometric fixed point of ice and water saturated with air at a pressure of 101 325 Pa.

industrial platinum resistance thermometer (IPRT), *n*—a rugged platinum resistance thermometer suitable for temperature measurements in harsh industrial environments over all or part of the temperature range –200 to 650 °C.

Discussion—(1) The sensing element is made from platinum wire or film and packaged in a rugged housing to withstand harsh operating conditions. The sheath material is usually stainless steel or Inconel; however, other materials may be used for special applications. (2) The resistance-temperature relationship is usually defined by a specified nominal equation and interchangeability tolerances over a specified temperature range. (3) IPRTs have ice-point resistance values of at least 100 ohm, and are available with two-wire, three-wire or four-wire terminations. (4) IPRTs are the most rugged and lowest cost platinum resistance thermometers.

International Practical Temperature Scale (IPTS-48), *n*—the temperature scale adopted by the 11th General Conference on Weights and Measures in 1960 and replaced in 1968 by the International Practical Temperature Scale of 1968.

International Practical Temperature Scale of 1968 (IPTS-68), *n*—the temperature scale adopted by the 13th General Conference on Weights and Measures in 1968.

Discussion—The IPTS-68 was superseded in 1990 by the International Temperature Scale of 1990.

International Temperature Scale of 1990 (ITS-90), *n*—the temperature scale prepared in accordance with instructions of the 18th General Conference on Weights and Measures, and adopted on January 1, 1990.

interpolation, *n*—the estimation of a value of a measurement between the values already measured by the estimation of a curve based on the measured values.

kelvin, K, *n*—base unit of temperature in the International System of Units (SI).

liquid-in-glass thermometer, *n*—a temperature-measuring instrument whose indications are based on the temperature coefficient of expansion of a liquid relative to that of its containing glass bulb.

lower range value, *n*—the lowest quantity that an instrument is adjusted to measure.

maximum permissible errors, *n—of a thermometer or thermometric system*, extreme values permitted by regulation or specification of the difference between the indication of a thermometer or thermometeric system and the true value of temperature.

Discussion—The term *tolerance* is sometimes used in ASTM standards to represent this concept.

maximum self-registering clinical thermometer, *n*—clinical thermometer designed to retain the indication of its maximum measured temperature until reset.

measuring junction, *n*—that junction of a thermocouple which is subjected to the temperature to be measured.

melting point, *n*—fixed point of a single component system in which liquid and solid phases are in equilibrium at a specified pressure, usually 101 325 Pa, and the system is gaining heat slowly. (Compare **freezing point**.)

mineral insulated metal-sheathed (MIMS) cable, *n*—a bendable cable consisting of one or more conductors embedded in a metal protecting sheath, insulated from each other and from the sheath by a compacted mineral material.

noble metal thermocouple, *n*—thermocouple whose thermoelements are composed primarily of noble metals and their alloys. (See also **base metal thermocouple; refractory metal thermocouple**.)

Discussion—Noble metals used in thermoelements include platinum, rhodium, gold, palladium, and iridium. Letter designated types B, R, and S are considered noble metal thermocouples.

partial immersion thermometer, *n*—a liquid-in-glass thermometer designed to indicate temperatures correctly when the bulb and a specified part of the stem are exposed to the temperatures being measured. (Compare **complete immersion thermometer** and **total immersion thermometer**.)

Peltier coefficient, *n*—the reversible heat which is absorbed or evolved at a thermocouple junction when unit current passes in unit time.

platinum 27 (Pt-27), *n*—the platinum standard to which the National Bureau of Standards referred thermoelectric measurements prior to 1973.

platinum 67 (Pt-67), *n*—the platinum standard used by the National Bureau of Standards after 1972 as the reference to which thermoelectric measurements are referred.

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

Discussion—Platinum resistance thermometers are available in a variety of designs for use over the general temperature range of –259 to 962 °C or portions thereof. The construction details of each PRT design (type of element, connecting wire construction, insulation, sealing, and mounting) are tailored to maximize the performance of the thermometer for the intended application and temperature range. (See also **Standard Platinum Resistance Thermometer (SPRT); Industrial Platinum Resistance Thermometer (IPRT); Secondary Reference PRT Thermometer**.)

precision, *n*—the scatter between individual values of test data within the subset, normally computed with respect to the mean of the subset. (See **bias**.)

probe cover and sheath, *n*—a device provided for the purpose of preventing biological contact between the patient and the probe or thermometer.

protecting tube, *n*—a tube designed to enclose a temperature-sensing device and protect it from the deleterious effects of the environment.

DISCUSSION—It may provide for attachment to a connection head but is not primarily designed for pressure-tight attachment to a vessel. (See also **thermowell**.)

radiation thermometer, *n*—a radiometer calibrated to indicate the temperature of a blackbody.

radiometer, *n*—a device for measuring radiant power that has an output proportional to the intensity of the input power.

range, *n—of a thermometer of thermometric system*, a set of temperatures within specified lower and upper tempurature limits.

DISCUSSION—The "operating range," "measuring range," "working range," or "scale range" is the set of exposure temperatures for the sensing portion of a thermometer or thermometric system that permits temperature measurements to be made with specified uncertainty. With certain liquid-in-glass thermometers, an auxiliary scale or reference scale is provided. The "range" of such liquid-in-glass thermometers includes only the "working range" or "measuring range" and does not include the auxiliary scale or reference scale (when applicable).

DISCUSSION—The "storage temperature range" or "non-operating temperature range" is set of exposure temperatures that the thermometer or thermometric system can endure without adversely affecting the ability to make temperature measurements with specified uncertainty when subsequently placed into service. Some specifications provide for a maximum increase in specified uncertainty after exposure to the storage temperature range for a specified period of time.

DISCUSSION—The "ambient temperature range" is the set of exposure temperatures that the indication or display portion of the thermometer or thermometric system can endure during the measurement process without adversely affecting the ability to make temperature measurements.

DISCUSSION—See also **span**.

reference junction, *n*—that junction of a thermocouple which is at a known temperature.

reference temperature, *n*—that temperature, however determined, whose value and accompanying uncertainty, are taken to be known in the calibration of thermometers or for other purposes.

DISCUSSION—This temperature can be determined through measurement using a calibrated thermometer such as a Standard Platinum Resistance Thermometer (SPRT), or through the realization of a thermometric fixed point cell with an assigned value. Examples of fixed point cells include the triple point of water cell and the freezing point of zinc cell, among others.

refractory metal thermocouple, *n*—(1) one whose thermoelements have melting points above 1935 °C (3515 °F). (2) thermocouple whose thermoelements are composed primarily of refractory metals and their alloys. (See also **base metal thermocouple; noble metal thermocouple**.)

DISCUSSION—Refractory metals used in thermoelements include tungsten, rhenium, and molybdenum.

repeatability, *n—of results of temperature measurements*, closeness of agreement between the results of successive measurements of the same temperature carried out under the same conditions of measurement.

DISCUSSION—(1) Repeatability conditions include the same measurement procedure; the same observer; the same thermometer or thermometeric system, used under the same conditions; the same location; and repetition over a short interval of time. (2) Repeatability may be expressed quantitatively in terms of the dispersion characteristics of the results such as the mean value and standard deviation.

reproducibility, *n—of results of temperature measurements*, closeness of agreement between the results of measurements of the same temperature carried out under changed conditions of measurement.

DISCUSSION—(1) A valid statement of reproducibility requires specification of the conditions changed. (2) The changed conditions may include principle of measurement, method of measurement, observer, thermometer or thermometric system, reference standard(s), location, conditions of use, and time. For ASTM standard test methods, the method is not changed. (3) Reproducibility may be expressed quantitatively in terms of the dispersion characteristics of the results such as the mean value and standard deviation. (4) Results are here usually understood to be corrected results.

resistance thermometer, *n*—a temperature-measuring device comprised of a resistance thermometer element, internal connecting wires, a protective shell with or without means for mounting, a connection head, or connecting wire or other fittings, or both.

resistance thermometer element, *n*—the temperature-sensitive portion of the thermometer composed of resistance wire, film or semiconductor material, its supporting structure, and means for attaching connecting wires.

secondary reference PRT thermometers, *n*—a general purpose laboratory reference thermometer (also referred to as "Secondary SPRT" and "Secondary Reference PRT") designed to be a suitable standard for routine temperature measurement over all or part of the range –200 to 650 °C.

DISCUSSION—(1) Secondary reference PRT thermometers have a sensing element made from strain-free platinum wire such that the finished thermometer meets the specified stability and repeatability requirements but not necessarily the acceptance criteria defined by the ITS-90. (2) Secondary reference PRT thermometers are typically configured with a long-stem metal sheath, have nominal ice-point resistance values between 25 and 100 ohm, and feature four-wire terminations. (3) The resistance-temperature relationship is usually defined by a thermometer-specific calibration and uncertainty applicable over a specified temperature range. (4) Secondary reference PRT thermometers have greater uncertainty than SPRTs but are generally more rugged and less costly.

secondary standard thermocouple, *n*—a thermocouple that has had its temperature-emf relationship determined by reference to a primary standard of temperature.

Seebeck coefficient, *n*—the change in thermoelectric emf per unit change of temperature at a given temperature for a thermoelement exposed to a thermal gradient.

DISCUSSION—The units of the Seebeck coefficient are volts per kelvin (V/K), although it is often expressed as microvolts per kelvin (μV/K). (See also **thermoelectric power**.)

Seebeck effect, *n*—a phenomenon in which a temperature-dependent electromotive force is generated between two points of a thermoelement that are at different temperatures; the Seebeck effect provides the physical basis for thermocouples.

Seebeck emf, *n*—an electrical potential difference between two points in a region of electrically conducting material that exists solely because of temperature gradients between those two points in the material.

sensor, *n—of a thermometer or thermometric system*, element of the thermometer or thermometric system that is directly affected by the temperature to be measured.

sheath-enclosed-scale thermometer, *n*—the cylindrical glass envelope which encloses the scale and capillary tube.

sheathed thermocouple, *n*—a thermocouple having its thermoelements, and sometimes its measuring junction, embedded in ceramic insulation compacted within a metal protecting tube.

sheathed thermocouple wire, *n*—one or more pairs of thermoelements (without measuring junction(s)) embedded in ceramic insulation compacted within a metal protecting tube.

sheathed thermoelement, *n*—a thermoelement embedded in ceramic insulation compacted within a metal protecting tube.

span, *n—of a thermometer or thermometric system,* the absolute value of the difference between the specified lower and upper temperature limits within a range.

standard platinum resistance thermometer (SPRT), *n*—a precision laboratory reference thermometer and defining interpolating instrument on the ITS-90 from approximately –259 to 962 °C or portions thereof.

DISCUSSION—(1) Standard platinum resistance thermometers have a sensing element made from strain-free platinum wire with sufficient purity such that the finished thermometer meets the acceptance criteria defined by the ITS-90. (2) Common SPRT configurations include the Capsule type (CSPRT), the Long-stem type (LSPRT), and the High Temperature type (HTSPRT). These configurations have nominal icepoint resistance values between 0.25 and 25 ohm, four-wire terminations, and are optimized to cover portions of the temperature range above. (3) The resistance-temperature relationship is defined by a thermometer-specific calibration and uncertainty applicable over a specified temperature range. (4) SPRTs are capable of achieving the lowest calibration uncertainty of any reference thermometer, but are relatively delicate and require careful handling to avoid damage caused by mechanical shock.

standard thermoelement, *n*—a thermoelement that has been calibrated with reference to platinum 67 (Pt-67).

stem, *n—of a liquid-in-glass thermometer*, capillary tube through which the meniscus of the thermometric liquid moves with change of temperature.

Style CU, *n*—designation for a common ungrounded measuring junction in a thermocouple assembly.

Style G, *n*—designation for a grounded measuring junction in a thermocouple assembly.

Style IU, *n*—designation for an isolated ungrounded measuring junction in a thermocouple assembly.

Style U, *n*—designation for an ungrounded measuring junction in a thermocouple assembly.

target plane, *n*—the plane, perpendicular to the line of sight of a radiation thermometer, that is in focus for that instrument.

temperature coefficient of resistance, α, *n*—the ratio of the fractional change in electrical resistance of a substance to a corresponding change in temperature of that substance.

DISCUSSION—(1) The temperature coefficient of resistance is given by $\alpha\ (T) = (1/R)\ (dR/dT)$, where α is the symbol representing the temperature coefficient of resistance, R is the resistance of the thermometer resistor at temperature T, and (dR/dT) is the first derivative of R with respect to T. (2) The dimension of α is reciprocal temperature. In general, $\alpha = \alpha\ (T)$ is a function of temperature. (3) For platinum resistance thermometers, over the temperature interval 0 to 100 °C, the platinum resistor has been characterized historically by an average temperature coefficient of resistance using $\alpha = (R_{100} - R_0)/100R_0$, where R_0 is the resistance at 0 °C and R_{100} is the resistance at 100 °C. The value of α for industrial platinum resistance thermometers specified in Specification E1137/E1137M can be derived from the coefficients A and B given in that standard using $\alpha = A + 100B$.

test thermoelement, *n*—a thermoelement that is to be calibrated with reference to platinum 67 (Pt-67) by comparing its thermal emf with that of a standard thermoelement.

thermal electromotive force (thermal emf), *n*—the net emf set up in a thermocouple under conditions of zero current. (Same as **Seebeck emf**.)

thermistor, *n*—a temperature sensor employing a semiconductor that exhibits a continuous change in electrical resistance with a change in sensor temperature (that is, a semiconductor for which the temperature coefficient of resistance over a specified temperature range is either negative or positive and exhibits no discontinuities).

DISCUSSION—(1) A negative temperature coefficient thermistor (NTC) is a ceramic semiconductor that exhibits a monotonic decrease in electrical resistance with an increase in sensor temperatures and exhibits no changes in sign. (2) A positive temperature coefficient thermistor (PTC) is a semiconductor that exhibits an increase in electrical resistance with an increase in sensor temperature when used within its normal operating range. One type of PTC thermistor exhibits a monotonic increase in electrical resistance with increasing temperature and exhibits no changes in sign. Another type of PTC thermistor has a transition or switching temperature that is determined by its physical composition. The temperature coefficient of resistance for this switching type device exhibits a slight negative value at temperatures below the transition temperature, becomes zero in the region of the transition temperature and then exhibits a large positive value at temperatures above the transition temperature. The electrical resistance of these switching PTC devices is a relatively low value at low body temperatures, decreases to a minimum value in the region of the transition temperature and then rapidly increases to an extremely high value as the device is heated above the transition temperature.

thermocouple, *n—in thermometry*, the sensor of a thermoelectric thermometer, consisting of electrically conducting circuit elements of two different thermoelectric characteristics joined at a junction.

thermocouple assembly, *n*—an assembly consisting of two thermocouple elements and one or more associated parts such as terminal block, connection head, and protecting tube.

thermocouple calibration, *n*—the process of determining the emf developed by a thermocouple with respect to temperature established by a standard.

thermocouple electromotive force (emf), *n*—the electrical potential difference between the open ends of the thermocouple's positive and negative thermoelements at the reference junction.

DISCUSSION—Thermocouple emf is dependent on the temperature difference between the thermocouple's measuring junction and reference junction.

thermocouple inhomogeneity, *n*—the variation of the thermoelectric properties of a thermocouple's thermoelements along their length.

DISCUSSION—This variation may exist in a new thermocouple, but it also may be due to the exposure of certain segments of the thermocouple to hot temperatures or harsh chemical environments. Inhomogeneity results in the deviation of a thermocouple's Seebeck coefficient at a given temperature from its normal Seebeck coefficient at that temperature. Thermocouple inhomogeneity is often reported as a fractional variation in the Seebeck coefficient.

thermoelectric power, *n*—(See **Seebeck coefficient**.)

thermoelectric properties, *n*—electrical properties of a material related to the electric potential gradient generated in the material by a temperature gradient in the material.

thermoelectric thermometer, *n*—thermometer for which the thermometric quantity is an emf produced by the Seebeck effect.

thermoelement, *n*—*in thermometry*, each of the materially dissimilar electrical conductors or circuit elements that comprise a thermocouple.

thermometric fixed point, *n*—fixed point useful in the practice of thermometry.

thermopile, *n*—a number of similar thermocouples connected in series, arranged so that alternate junctions are at the reference temperature and at the measured temperature, to increase the output for a given temperature difference between reference and measuring junctions.

thermowell, *n*—a closed-end reentrant tube designed for the insertion of a temperature-sensing element, and provided with means for pressure-tight attachment to a vessel. (See also **protecting tube**.)

tolerance, *n*—the defined limits of allowable deviation from a standard in a measured quantity or other value such as temperature, relative humidity, resistance, and so forth; when the term is used for a measurement instrument or system, it refers to the permitted variation of a measured value from the correct value. (See also **error; maximum permissible error**.)

DISCUSSION—The tolerance may be specified as a factor or percentage of the nominal value; a maximum deviation from a nominal value; an explicit range of allowed values; or, be implied by the numeric accuracy of the nominal value. Tolerance can be symmetrical or asymmetrical. When the term is used in quality control, it refers to the limiting values between which measurements must lie if an article is to be acceptable, as distinct from confidence limits. The term "tolerance" should not be used to designate "maximum permissible error."

total immersion thermometer, *n*—a liquid-in-glass thermometer designed to indicate temperatures correctly when just that portion of the thermometer containing the liquid is exposed to the temperature being measured. (Compare **complete immersion thermometer** and **partial immersion thermometer**.)

traceability, *n*—*of a temperature measurement*, the ability to relate, with scientific credibility, the result of a temperature measurement and its associated uncertainty to a stated temperature scale through a sequence of comparisons with references, usually national or international standards, whose values have been determined on the scale with stated uncertainty.

triple point, *n*—fixed point of a system in which three phases are in equilibrium.

triple point of water, *n*—triple point of the liquid, solid, and vapor phases of water.

DISCUSSION—The idealized triple point of water, to which a value of 273.16 K (0.01 °C) is assigned, is a defining fixed point for both the Kelvin Thermodynamic Temperature Scale (KTTS) and the International Temperature Scale of 1990 (ITS-90).

true value, *n*—*of a temperature*, value attributed to a particular temperature and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose.

DISCUSSION—(1) For example, in a given situation, the value assigned to a temperature determined by measurement with a reference standard thermometer may be taken as a true value. (2) This concept is often designated by the term *conventional true value.*

uncertainty, *n*—*of a temperature measurement*, parameter, derived from an analysis of a measurement and its result, that characterizes the range in which the true value of temperature is estimated to lie, generally with a given confidence.

DISCUSSION—The parameter may be, for example, a standard deviation (or a multiple of it), or the half-width of an interval having a stated level of confidence.

DISCUSSION—The parameter has many components. Some components may be evaluated by statistical methods; others may be based on experience, using assumed probability distributions.

ungrounded junction, *n*—measuring junction within a thermocouple assembly that is electrically isolated from its sheath. (See also **Style U**.)

upper range-value, *n*—the highest quantity that an instrument is adjusted to measure.

3.2 *Definitions of Terms Specific to Standards in Which They Appear:*

absolute zero, *n*—a temperature of 0 K (–273.15 °C). **E2758**

accuracy, *n*—ability of an *infrared thermometer* to give a reading close to the *true temperature.* **E1965**

accuracy class, *n*—class of an item that meets certain metrological requirements intended to keep errors within specified limits.

DISCUSSION—This document describes accuracy classes for digital thermometers. **E2877**

adjacent thermoelement configuration, *n*—thermoelement configuration within a multi-pair thermocouple or cable where two or more positive thermoelements are immediately adjacent to one another around the circular pattern and two or more negative thermoelements are also immediately adjacent to one another around the circular pattern as shown in Fig. 1 (compare with alternating thermoelement configuration in Fig. 2 and 3.2.2).

DISCUSSION—By default, a multi-pair thermocouple or cable with a thermoelement in the center shall be considered an adjacent configuration. **E2181/E2181M**

adjusted mode, *n*—output of an *IR thermometer* that gives temperature measured and calculated from a subject or object, by correcting such temperature for variations in ambient temperature, *subject's* temperature, emissivity, body site (that is, *oral*, or *rectal*), etc. **E1965**

adjusting device, *n*—a section of the instrument used to adjust the amount of mercury in the bulb and main capillary to that needed for the intended temperature interval. **E1**

alpha (α), *n*—the temperature coefficient of resistance of a PRT over the range 0 to 100 °C. **E1137/E1137M**

alternating thermoelement configuration, *n*—thermoelement configuration within a multi-pair thermocouple or cable where positive thermoelements and negative thermoelements alternate around the circular pattern as shown in Fig. 2 (compare with adjacent thermoelement configuration in Fig. 1 and 3.2.1).

DISCUSSION—In an alternating thermoelements pattern, there are never two or more positive thermoelements nor two or more negative thermoelements immediately adjacent to one another. **E2181/E2181M**

amorphous silica fiber, *n*—a continuous filament of heat insulating material whose principal constituent is amorphous silica. **E574**

annealing, *v*—a heat treating process intended to stabilize resistance thermometers prior to calibration and use. **E2593**

API gravity, *n*—the gravity obtained from the following relationship:

$$API\ \text{Gravity, deg} = 141.5/(\text{sp gr } 60/60\ °\text{F}) - 131.5 \quad (1)$$

E126

atmospheric attenuation, *n*—a ratio showing how much thermal radiation in a given spectral range is absorbed or scattered in air over a given distance. **E2758**

atmospheric transmission, *n*—a ratio showing how well thermal radiation in a given spectral range at a given distance travels through a certain distance of air. **E2758**

attenuating medium, *n*—a semi-transparent solid, liquid or gas, such as a window, filter, external optics, or an atmosphere that reduces thermal radiation, or combinations thereof. **E2758**

axial temperature uniformity, *n*—temperature differences along the immersed length of the thermometer boring under test.

DISCUSSION—Axial temperature uniformity is sometimes referred to as axial temperature homogeneity. **E3186**

axillary temperature, t_{ba}, *n*—temperature at the apex of either axilla (armpit) as measured by a *contact thermometer.* **E1965**

background radiation—see *reflected radiation*. **E2758**

band width or span (Δ), *n*—the temperature difference defined by the equation:

$$\Delta = SB - SR \quad (2)$$

E1061

band width or span (Δ), *n*—the temperature difference defined by the following equation:

$$\Delta = T°470 - T°650 \quad (3)$$

E1061

bath gradient error, *n*—the error caused by temperature differences within the working space of the bath. **E2488**

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. **E644**

battery charger, *n*—an electrical circuit designed to restore the electrical potential of a battery. **E1112**

blackbody, *n*—the perfect or ideal source of thermal radiant power having a spectral distribution described by Planck's Law. **E2758**

blackbody, *n*—a reference source of infrared radiation made in the shape of a cavity and characterized by precisely known temperature of the cavity walls and having effective emissivity at the cavity opening arbitrarily considered equal to unity. **E1965**

blackbody simulator, *n*—a device with an emissivity close to unity that can be heated or cooled to a stable temperature. **E2758**

blackbody temperature, t_{BB}, *n*—temperature of blackbody cavity walls as measured by an imbedded or immersed *contact thermometer.* **E1965**

bladder temperature, *n*—temperature of the interior of urinary bladder as measured by a *contact thermometer.* **E1965**

block-loading error, *n*—temperature reading error as a result of temperature uniformity profile in the block changes with the number and size of thermometers in the block. **E3186**

body temperature, *n*—temperature measured from the interior of a human body cavity, such as pulmonary artery, distal esophagus, urinary bladder, ear canal, oral, or rectal. **E1965**

bore, *n*—the hole or lumen in the stem. **E667**

boring, *n*—machined hole in the dry block that can accommodate various sizes of thermometers and removable sleeves.

DISCUSSION—These are also referred to as wells. **E3186**

bulb length, *n*—the distance from the bottom of the bulb to the junction of the bulb and the stem tubing. **E2251**

bulb length, *n*—the distance from the bottom of the bulb to the junction of the bulb and the stem tubing. **E1**

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. **E780, E839**

cable end closure, *n*—a moisture barrier at the cable end of the sheath.

DISCUSSION—This does not necessarily constitute a hermetic seal. **E1137/E1137M**

calibration, *n*—the determination of the indications of a thermometer with respect to temperatures established by a standard resulting in scale corrections to be applied when maximum accuracy is required. **E77**

calibration, *n*—the determination of the resistance-temperature relationship for a specific thermometer; he resistance-temperature relationship may be specified as the ratio of the resistance of the thermometer at a given temperature to its resistance at the ice point as a function of the temperature, or simply as the resistance of the thermometer as a function of the temperature. **E644**

calibration adjustment, *n*—the correction to an IR thermometer based on its calibration. **E2758**

calibration date, *n*—the date on which the scale is affixed to a thermometer. **E667**

calibration uncertainty, *n*—parameter, derived from the analysis of a calibration of a measuring instrument, that characterizes the range in which the true calibration result is estimated to lie within a given confidence level. **E2877**

cavity bottom, *n*—the portion of the cavity radiation source forming the end of the cavity.

DISCUSSION—The cavity bottom is the primary area where an infrared thermometer being calibrated measures radiation. **E2847**

cavity radiation source, *n*—a concave shaped geometry approximating a perfect blackbody of controlled temperature and defined emissivity used for calibration of radiation thermometers.

DISCUSSION—A cavity radiation source is a subset of thermal radiation sources.

DISCUSSION—To be a cavity radiation source of practical value for calibration, at least 90 % of the field-of-view of a radiation thermometer is expected to be incident on the cavity bottom. In addition, the ratio of the length of the cavity versus the cavity diameter is expected to be greater than or equal to 5:1. **E2847**

cavity walls, *n*—the inside surfaces of the concave shape forming a cavity radiation source. **E2847**

celestial radiation, *n*—flux coming from the sky. **E2758**

center green (CG) or mid green (MG), *n*—that temperature which unifies the visual and instrumental evaluation methods and is defined by the equation:

$$CG = MG = \frac{SG + SB}{2} = T\ °520 \quad (4)$$

See 3.2.7.2 for description of T °520. **E1061**

center wavelength, *n*—the simple average of the lower and upper spectral range limits. **E2758**

ceramic marking, *n*—marking by fusing a ceramic colorant onto the glass surface. **E667**

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. **E2593**

clinical accuracy, *n*—ability of an infrared ear canal thermometer to give a reading close to *true temperature* of the site that it purports to represent. **E1965**

clinical bias, $\bar{x}_d$, *n*—mean difference between IR thermometer output and an internal body site temperature from *subjects* at specified conditions of ambient temperature and humidity and averaged over a selected group of subjects. **E1965**

clinical repeatability, s_r, *n*—pooled standard deviation of changes in multiple *ear canal temperature* readings as taken from the same subject from the same ear with the same *infrared thermometer* by the same operator within a relatively short time. **E1965**

cold-laps, *n*—sheath surface defects where the sheath surface has been galled and torn by a drawing die and the torn surfaces smoothed by a subsequent diameter reduction. **E839**

color play, *n*—the predictable sequence of colors exhibited by a liquid crystal formulation as it passes through its active temperature range (or example, as temperature increases, a formulation exhibits successive tan, red, green, and blue colors). **E1061**

combined site offset, μ_s, *n*—calculated difference in degrees of measured temperature between a selected reference body site and *ear canal temperature* and averaged over the population of representative study samples. **E1965**

common ungrounded junction, *n*—measuring junction within the same multi-pair thermocouple that is electrically isolated from the sheath but electrically connected to another ungrounded junction. **E2181/E2181M**

common ungrounded junction, *n*—measuring junctions within the same multi-pair thermocouple assembly that are electrically isolated from the sheath but electrically connected to each other. (See also **Style CU**.) **E608/E608M**

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 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. **E644**

connecting wires, *n*—the wires that run from the element through the cable end closure and external to the sheath. **E1137/E1137M**

connector pair, *n*—an assembly consisting of a plug and a jack, each having both positive and negative inserts, that will connect two parts of an electrical circuit and provide a means of physically disconnecting the two parts without the use of tools. **E1129/E1129M, E1684/E1684M**

constriction, *n*—an obstruction in the bore of a clinical thermometer which permits the passage of mercury from the bulb when the bulb is heated, but which restricts its passage back to the bulb when heat is removed. **E667**

contact inserts, *n*—metallic conductor assemblies which, when installed in connector bodies, provide connections between two parts of an electrical circuit; plug connectors will contain projecting prong contacts, while jack connectors will contain recessed socket or receptacle contacts. **E1129/E1129M, E1684/E1684M**

contact thermometer, *n*—an instrument that is adapted for measuring temperature by means of thermal conductance by determining the temperature at the moment when negligible thermal energy flows between the thermometer and the object of measurement. **E2758**

contact thermometer, *n*—an instrument that is adapted for measuring temperature by means of thermal conductivity by determining temperature at the moment when negligible thermal energy flows between the thermometer and the object of measurement. **E1965**

contraction chamber, *n*—an enlargement of the capillary, located below the main scale or between the main scale and the auxiliary scale, that serves to reduce the scale length or to prevent contraction of all the liquid column into the bulb. **E2251**

contraction chamber, *n*—an enlargement of the capillary, that will appear below the main scale or between the main scale and the auxiliary scale, which serves to reduce its length or to prevent contraction of the liquid column into the bulb. **E1**

core temperature, t_c, *n*—temperature at a *subject's* body site, such as pulmonary artery, distal esophagus, urinary bladder, or tympanic membrane, recognized as indicative of internal body temperature and obtained with a *contact thermometer.* **E1965**

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

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. **E2623**

correction, *n*—an offset value added to the result of a measurement to obtain a correct result.

DISCUSSION—This definition is from Test Method E220. **E2730**

coverage factor, *n*—numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty. **E2593**

customer, *n*—the individual or institution to whom the calibration or accuracy verification is being provided. **E2847**

density, *n*—the mass of a unit volume of material. **E126**

dew point, *n*—the temperature at which water vapor condenses into liquid water. **E2758**

diameter, *n*—the largest outside dimension of the glass tubing as measured with a ring gage. **E2251**

diameter, *n*—the largest outside dimension of the glass as measured with a ring gauge. **E1**

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. **E2593**

diffuse reflector, *n*—a surface that produces a diffuse image of a reflected source. **E2758**

digital contact thermometer, *n*—a device that measures temperature through direct contact with a sensor and provides a digital output or display of the determined value, or both.

DISCUSSION—This device consists of a temperature sensor connected to a measuring instrument; this instrument measures the temperature-dependent quantity of the sensor, computes the temperature from the measured quantity, and provides a digital output or display of the temperature, or both. The sensor is sometimes located inside the instrument. **E2877**

displayed temperature range, *n*—temperature range in degrees Celsius or Fahrenheit that can be shown by an *IR thermometer.*

dissipation constant, δ, *n*—the ratio of the change in energy dissipated per unit time (power) in a thermistor, $\Delta\dot{Q} = \dot{Q}_2 - \dot{Q}_1$, to the resultant temperature change of the thermistor, $\Delta t = t_2 - t_1$.

$$\delta = \frac{\Delta \dot{Q}}{\Delta t} \tag{5}$$

The dimensions of the dissipation constant are W/°C. For this specification, t_1 is in the range from 20 to 38 °C and Δt = 10 °C. **E879**

distance ratio, *n*—the ratio of the measuring distance to the diameter of the field-of-view, when the target is in focus. **E2758**

distance-to-size ratio (D:S), *n*—see *field-of-view*. **E2847**