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Terminology Relating to Thermometry and Hydrometry[1]

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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.

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 a Reference Thermoelement of Similar EMF-Temperature Properties
E220 Test Method for Calibration of Thermocouples By Comparison Techniques
E230 Specification and 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
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for Comparing EMF Stabilities of Base-Metal Thermoelements in Air Using Dual, Simultaneous, Thermal-EMF Indicators (Withdrawn 2006)[3]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 Thermocouple 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
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, Thermocouples Assemblies, and Connecting Wires Prior to, and

[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.

After Installation or Service
E1502 Guide for Use of Fixed-Point Cells for Reference Temperatures
E1594 Guide for Expression of Temperature
E1684 Specification for Miniature Thermocouple Connectors
E1750 Guide for Use of Water Triple Point Cells
E1751 Guide for Temperature Electromotive Force (EMF) Tables for Non-Letter Designated Thermocouple Combinations (Withdrawn 2009)[3]
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
E2593 Guide for Accuracy Verification of Industrial Platinum Resistance Thermometers

2.2 *Other Standards, Supplementary Vocabularies, and Sources:*[4]

International Vocabulary of Basic and General Terms in Metrology (VIM) 1993
Guide to the Expression of Uncertainty in Measurement (GUM) 1995
IEC 61298-1 Process Measurement and Control Devices General Methods and Procedures for Evaluating Performance- Part 1: General Considerations[5]

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.

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, 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 establish, under specified conditions, the relationship between the values of a thermometric quantity indicated by a thermometer or thermometric system and the corresponding values of temperature realized by standards.

DISCUSSION—(1) The result of a calibration permits either the assignment of values of temperature to indicated values of thermometric quantity or determination of corrections with respect to indications. (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 or a calibration report. (4) The term *calibration* has also been used 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—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.

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[5] Available from International Electrotechnical Commission (IEC), 3 rue de Varembé, Case postale 131, CH-1211, Geneva 20, Switzerland, http://www.iec.ch.

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 wires).**

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. Also see 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 °C 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 ohms, 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.

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**.)

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, 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 °C 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) and **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 exposer 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 exposer 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 °C 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 ohms and 100 ohms, 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 coefficent 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 °C 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 ohms and 25 ohms, 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 °C 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** and **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. Also see Style U.

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

3.2 *Definitions of Terms Specific to This Standard:*

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

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

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

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

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

E126

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

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 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*—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 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**

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—the hole or lumen in the stem. **E667**

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—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. The 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 date—the date on which the scale is affixed to a thermometer. **E667**

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**

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

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—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. For 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 junctions within the same multi-pair thermocouple assembly that are electrically isolated from the sheath but electrically connected to each other. Also see 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**

constriction—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**

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, 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**

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

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

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, $\Delta t = t_2 - t_1$.

$$\delta = \frac{\Delta\dot{Q}}{\Delta t} \quad (5)$$

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

distributor, *n*—any person who furthers the marketing of a device from the original manufacturer to the person who makes final delivery or sale to the ultimate consumer or user but who does not repackage or otherwise change the container, wrapper, or labeling of the device or device package. **E1112**

dope, *vt*—in this specification, to add potassium, silicon and aluminum compounds to the alloy powders during the preparation to produce a ductile wire. See NASA CR-72884.[6]

DISCUSSION—Alloy powders are doped. **E696**

[6] Preston-Thomas, H., "The International Temperature Scale of 1990 (ITS-90)," *Metrologia*, Vol 27, No. 1, 1990, pp. 3–10. For errata see *ibid*, Vol 27, No. 2, 1990, p. 107.

dry, *adj*—a condition which does not exceed the equivalent of 50 % relative humidity at 22 °C. **E780**

dumet, *n*—round, copper-coated 42 % nickel-iron wire intended primarily for sealing to soft glass. Also known as CuNiFe in some communities. **E879**

duplex wire, *n*—a matched pair of parallel, solid thermoelements, individually insulated (double wrap or braid) with insulating fibers and a fiber braid of the same material overall. **E574**

ear canal temperature, t_{ec}, *n*—displayed unadjusted temperature measured from the *field of view* of an *IR thermometer* whose *probe* is placed into the auditory canal of a *subject* according to the manufacturer's recommendations. **E1965**

E-glass, *n*—a family of calcia-alumina-silicate glasses that are used for general purposes and most electrical applications. **E574**

electronic thermometer, *n*—an instrument that provides a display of temperature sensed through the use of a transducer and electronic circuitry. **E1112**

emf stability—the change in emf output expressed in millivolts (or in equivalent degrees), over a period of time. **E601**

emf stability—the change in output expressed in millivolts (or in equivalent degrees if the thermoelectric power is known) occurring over a specified time at a specified temperature. **E710**

equalizing block—an object, usually metal, that when placed in a nonuniform temperature region, has greater temperature uniformity (due to its relatively high thermoconductivity and mass) than the medium surrounding the object. **E452**

etch—to attack the surface of glass with hydrofluoric acid or other agent, generally for marking or decoration. **E667**

excitation, *n*—the electrical current passing through the element. **E1137/E1137M**

expansion chamber, *n*—an enlargement at the top of the capillary to provide protection against breakage caused by excessive gas pressure. **E1**

extension wires, *n*—wires of either Seebeck matching or of compensating extension wire type used to extend the effective length of the thermoelements. Compensating extension wires match the Seebeck coefficient only over a limited temperature range. **E1350**

field of view, *n*—area of a subject's surface that exchanges thermal radiation with the sensor. **E1965**

finished thermocouple material—sheathed thermocouple material fabricated in final form, ready for delivery to the purchaser. **E585/E585M**

finished thermocouple material—sheathed thermocouple material in final form, fabricated, and tested in accordance with Specification E585/E585M. **E608/E608M**

fire cracks—cracks in glass caused by local temperature shock. **E667**

first cryoscopic constant, A, *n*—a constant of proportionality between the freezing point depression of, and concentration of impurities in, a sample of reference material, given by the ratio of the molar heat of fusion of the pure material, L, to the product of the molar gas constant, R, and the square of the thermodynamic temperature of fusion, T, of the pure material (freezing point):

$$A = \frac{L}{RT^2} \tag{6}$$

. **E1502**

flat magnifying lens—thermometer stem glass in which the numerals, graduations, and lens lie on the same relative surface. It is so named for its approximately flat cross section. **E667**

fractures—internal or external breaks or cracks in the glass. Internal fractures usually occur in the area between the bulb and the constriction. **E667**

freeze, *n*—an experiment or test run conducted with a freezing-point cell while the reference material in the cell solidifies. **E1502**

freezing curve, *n*—the entire time-temperature relation of the reference material in a freezing-point cell during freezing, including initial cooling, undercool, recalescence, freezing plateau, and final cooling to complete solidification. **E1502**

freezing-point cell, *n*—a device that contains and protects a sample of reference material in such a manner that the freezing point of the material can establish a reference temperature. **E1502**

freezing plateau, *n*—the period during freezing in which the temperature does not change significantly. **E1502**

freezing range, *n*—the range of temperature over which most of the reference material in a freezing-point cell solidifies. **E1502**

g-level, *n*—the acceleration of an object relative to the local acceleration of gravity.

DISCUSSION—For example, a g-level of 5 is equivalent to an acceleration of approximately $5 \times 9.8\ m/s^2 = 49.0\ m/s^2$. **E1137/E1137M**

graduations—series of lines on the stem of the thermometer which designate the temperature scale intervals. **E667**

hard shaker thermometer—a thermometer in which the constriction is overly severe thereby restricting the passage of mercury back to the bulb causing the thermometer to fail the ease-of-resetting requirements. **E667**

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. **E644**

impregnate, *vt*—to saturate the fiber insulation of wires with a high-temperature electrical insulating compound to form a moisture barrier around the wires and to inhibit fraying of the fibers. **E574**

index—the upper point of the mercury column whose position, when noted with respect to the corresponding numerals and graduations, indicates the temperature of the mercury within the bulb. **E667**

infrared (IR), *adj*—of the electromagnetic radiation within the mid- and far infrared spectral ranges (approximately from 3 to 30 μm wavelength). **E1965**

infrared (IR) thermometer, *n*—optoelectronic instrument adapted for noncontact measurement of temperature of a subject by utilizing *infrared* radiation exchange between the *subject* and the *sensor.* **E1965**

inner melt, *n*—a thin continuous layer of water between the thermometer well and the ice mantle of a water triple-point cell. **E1750**

instrumentational offset, μ_d, *n*—calculated difference in degrees of measured temperature between *core temperature* and *ear canal temperature*, derived from the population of representative study samples. **E1965**

insulation compaction density—the density of a compacted powder is the combined density of the powder particles and of the voids remaining after the powder compaction. Sometimes the insulation compaction density is divided by the theoretical density of the powder particles to obtain a dimensionless fraction of theoretical density as a convenient method to express the relative compaction. **E839**

insulation resistance, dc, *n*—the resistance at a specified direct-current voltage between the insulated leads of a thermistor sensor and the metallic enclosure of the sensor, if such an enclosure is present, or else between the sensor leads and a conductive medium in which the sensor is immersed. **E879**

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.) **E644**

intermittent human temperature determination—determination of human body temperature that is made periodically by a series of entirely separate measurements. **E825**

internal, *adj*—of the interior of *subject's* body or body cavity, such as pulmonary artery, urinary bladder, oral, rectal, etc. **E1965**

interval error, *n*—the deviation of the nominal value of a temperature interval from its true value; either for the total range (total interval) or for a part of the range (partial interval). **E1**

IR thermometer type, *n*—an optoelectronic instrument that is capable of noncontact *infrared* temperature measurement when placed into the auditory canal of a *subject* (ear canal type) or from the *subject's* body surface (skin type). **E1965**

IR thermometer, *n*—an optoelectronic instrument that is capable of noncontact infrared temperature measurement when placed into the auditory canal of a subject (ear canal type) or from the subject's body surface (skin type). **E1112**

isolated ungrounded junction, *n*—measuring junctions within the same multi-pair thermocouple assembly that are electrically isolated from the sheath and electrically isolated from each other. See also Style IU. **E608/E608M**

junction class, *n*—the electrical connectivity of a junction. Style U junctions are electrically isolated from conductive sheaths and from reference ground. Style G junctions are electrically connected to conductive sheaths. **E1350**

laboratory error, δ, *n*—difference between *unadjusted temperature* as measured by an *IR thermometer* and temperature of a blackbody, over specified operating conditions of ambient temperature and humidity and *blackbody* temperature ranges. **E1965**

length of the bulb—the distance from the bottom of the bulb to the junction of the bulb and the lower part of the sheath; that is, the point where the internal bulb diameter begins to decrease as the bulb merges into the capillary tube. **E1**

length of the scale, *n*—the length of the nominal range in the stem, not including graduations extending above and below the nominal limits. **E100**

lot, *n*—a quantity of thermocouples manufactured from the same continuous length of mineral-insulated, metal-sheathed thermocouple cable. **E608/E608M**

lot, *n*—that quantity of finished thermocouple material manufactured from: tubing from the same heat; wire from the same spool and heat; insulation from the same batch; assembled and processed together under controlled production conditions, to the required final outside diameter. **E585/E585M**

magnifying lens—stem glass which, due to its configuration, results in a magnification of the mercury column. **E667**

manufacturer, *n*—any person, including any repacker or relabeler, or both, who manufactures, fabricates, assemblies, or reprocesses a finished device. (See "Good Manufacturing Practices," Part 807 Code of Federal Regulations 6.) **E1112**

manufacturing lot, *n*—(*1*) in the case of continuous manufacturing processes, a *lot* is a specifically identified amount produced in a unit of time or quantity in a manner that assumes its having uniform characteristics and quality within specified limits. (*2*) In the case of batch processes, a *lot* means a batch or specifically identified portion of a batch assumed to have uniform characteristics and quality within specified limits. **E1061**

manufacturing lot—in the case of continuous manufacturing process, a lot is a specific identified amount produced in a

unit of time or quantity in a manner that assures its having uniform character and quality within specified limits. In the case of batch process, a lot means a batch or specific identified portion of a batch having uniform character and quality within specified limits. **E825**

matched pairs, *n*—a set of positive and negative thermoelements chosen so that a thermocouple fabricated from these thermoelements will match a specified temperature-elctromotive force relationship to within a specified tolerance, at the time of first use. **E1751**

measurement time, *n*—that time required from the time of patient contact to display of temperature to within the stated accuracy. **E1112**

measurement time, *n*—the period required from the time of patient contact to the time when the thermometer may be removed or read to within the stated accuracy of the thermometer. **E825, E1104**

metal sheathed cable stripper, *n*—a tool used to remove a selected portion of the metal sheath from an end of sheathed thermocouple material. **E780**

minimum immersion length, *n*—the depth that a thermometer should be immersed, in a uniform temperature environment, such that further immersion does not produce a change in indicated temperature greater than the specified tolerance. **E1137/E1137M**

mode, *n*—an output of an *IR thermometer* that gives a representation of a temperature using a disclosed calculation technique with respect to selected reference (for example, *blackbody, oral, rectal*, etc.). **E1965**

nonreactive, *adj*—a condition which will not produce a chemical transformation or change. **E780**

normal human temperature—the conventionally accepted average body temperature in healthy human beings (37 °C or 98.6 °F). **E667**

nucleation, *n*—the formation of crystal nuclei in liquid in the supercooled state. **E1502**

operating humidity, *n*—relative humidity of ambient air which allows operation of an *IR thermometer* within a specified *laboratory error* range. **E1965**

operating temperature, *n*—ambient temperature that allows operation of an *IR thermometer* within specified *laboratory error* range. **E1965**

oral temperature, t_{bm}, *n*—posterior sublingual temperature as measured by a *contact thermometer.* **E1965**

ovulation thermometer—a thermometer specifically designed for obtaining body temperature for the purpose of determining the date of ovulation or the basal body temperature. **E667**

patient—any human whose temperature is being taken. **E1104**

phase change-type disposable fever thermometer—one-time use instrument utilizing the melting of compounds to measure and indicate an anatomical site temperature. **E825**

phase change-type fever thermometer—a reusable instrument utilizing the change of state of chemical compositions to measure and indicate an anatomical site temperature. **E1299**

physiological site offset, μ_p, *n*—difference in degrees of measured temperature between two body sites derived from the representative study samples. **E1965**

polycrystalline fiber, *n*—a continuous polycrystalline filament of heat insulating material whose composition is alumina, boria, and silica in an approximate ratio of 3:1:2, respectively. **E574**

predictive thermometer—any thermometer that indicates the true temperature of a measurement site in a time shorter than that necessary for the thermometer to reach equilibrium temperature of that site. **E825**

predictive thermometer, *n*—one that provides an indication of the final stabilized temperature of the measurement site in advance of the time necessary for the transducer to reach a stabilized temperature. **E1112**

probe, *n*—an assembly, including the transducer, that is used to position the transducer in the specific location at which the temperature is to be determined. **E1104, E1112**

probe, *n*—part of an *IR thermometer* that channels net *infrared* radiation between the *subject* and the *sensor* and is intended to be positioned near or inside the *subject.* **E1965**

probe cover, *n*—disposable or reusable sanitary barrier enveloping that part of the *probe* which otherwise would come in contact with a *subject.* **E1965**

probe cover and sheath, *n*—a device provided for the purpose of preventing biological contact between the patient and probe (see Specification E1104). **E1112**

probe covers and sheaths, *n*—devices provided for the purpose of preventing biological contact between the patient and the probe or clinical thermometer. **E1104**

production run—the quantity of BMLs (produced at one time and from the same material lot) that travel together continuously through the same processing steps, that is, assembly, size reduction, annealing, etc. **E839**

professional use, *n*—intended or implied use of an instrument by individuals that are licensed or certified for collecting information for medical diagnosing purposes. **E1965**

PRT design, *n*—a generic term used to differentiate between different PRT construction details, such as element and connecting wire construction, insulation methods, sealing techniques, and mounting methods (for example, spring loaded or direct mounting). **E1137/E1137M**

qualification test, *n*—a series of tests conducted by the procuring agency or an agent thereof to determine conformance of thermistor sensors to the requirements of a specification, normally for the development of a qualified products list under the specification. **E879**

radiation thermometer, *n*—an electronic device that relies on the emitted radiation from a target to access the target's temperature. E1112

raw material—material components (tubing, insulators, and wires) as received, prior to any manufacturing procedures. E839

raw material—material components (tubing, insulators, and wires) used in fabrication of the sheathed thermocouple material. E585/E585M

recalescence, *n*—the sudden increase in temperature of reference material in the supercooled state upon nucleation and crystal growth, due to the release of latent heat of fusion of the reference material. E1502

rectal temperature, t_{br}, *n*—temperature in the anal canal as measured by a *contact thermometer.* E1965

reference facility, *n*—NIST, or a testing laboratory whose physical standards are traceable to NIST or another national standards laboratory. E207

reference material, *n*—the material in a freezing-point cell that melts and freezes during use, the freezing point of which can establish a reference temperature. E1502

reference point, *n*—a temperature at which a thermometer is checked for changes in the bulb volume. E77

reference temperature, *n*—a fixed, reproducible temperature, to which a value is assigned, that can be used for the calibration of thermometers or other purposes. E1502

reference temperature, *n*—the temperature of a phase equilibrium state of a pure substance at a specified pressure, for example, the assigned temperature of a fixed point.

DISCUSSION—At an equilibrium state of three phases of a substance, that is, at the triple point, both the temperature and pressure are fixed. E1750

reference temperature source, *n*—a source of thermal radiant power of known temperature or emissivity, or both, used in the testing of radiation thermometers. E1256

reference thermometer—a thermometer whose calibration is known within a certain specified accuracy. E220

reflecting stem—stem glass containing a colored stripe along its length in a location which, when reflected on the mercury column, allows greater contrast and enables the column to appear tinted. E667

reliability—the probability of performing without failure a specified function under normal conditions for a specified period of time. E667

residual mercury column—the mercury that lies in the bore of the stem above the constriction. E667

resolution, *n*—minimum temperature increment displayed by an *IR thermometer* in degrees Celsius or Fahrenheit. E1965

response time, *n*—the time required for a sensor to change a specified percentage of the total difference between its initial and final temperatures as determined from zero-power resistances when the sensor is subjected to a step function change in temperature. E879

retention time—the duration of time that the optimal signal for reading persists. E1299

retreating index thermometer—a thermometer in which the constriction is not sufficiently small to prevent the passage of mercury back to the bulb (or the mercury index from falling) without shaking when heat is removed from the bulb. E667

saddle, *n*—the bottom support of the enclosed scale. E1

scale, *n*—graduation of temperature display in degrees Celsius or Fahrenheit. E1965

scale range—the range of degrees of temperature through which a thermometer is usable. E667

self-heating, *n*—the change in temperature of the element caused by the heating effect of the excitation. E1137/E1137M

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. E644

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. E644

sensing circuit, *n*—the combination of the thermoelements and extension wires, but excluding active signal conditioning components such as reference junction compensators, amplifiers and transmitters. E1350

sensor, *n*—device designed to respond to net *IR* radiation and convert that response into electrical signals. E1965

sequencing, *n*—a characteristic whereby the thermal profiles of the liquid crystal formulations of a given thermometer follow each other in an orderly predetermined manner. E1061

service life, *n*—the interval of time that a connector assembly will be put to use and retain all physical and thermoelectric properties. E1684

setting temperature, *n*—the temperature that yields a reading of zero on the main scale for a given adjustment of the amount of mercury in the bulb and main capillary. E1

S-glass, *n*—a family of magnesia-alumina-silicate glasses with a higher tensile strength and higher softening temperature than E-glass. E574

sheath, *n*—a cylindrical metal tube with an integral welded closure at the end in which the element is located. E1137/E1137M

sheathed-thermocouple assembly, *n*—the cut-to-length finished assembly consisting of thermoelements having one end joined in a measuring junction, and contained within and electrically isolated from, a protective sheath closed at the measuring end, except the thermoelements of the class G thermocouple join the sheath at the junction. The protective sheath has a moisture seal at the reference junction end of the sheath. The assembly may include a thermocouple connector but does not include a reference junction or extension leads mechanically joined to the thermoelements. **E1350**

sheathed thermocouple material—an assembly of two solid continuous thermoelements embedded in ceramic insulation compacted within a metal protecting sheath. **E585/E585M, E608/E608M**

sheathed thermocouple material, *n*—a combination of two or more continuous thermoelements embedded in ceramic insulation compacted within a metal protecting sheath. **E608/E608M**

short range ordering—the reversible short-ranged, order-disorder transformation in which the nickel and chromium atoms occupy specific (ordered) localized sites in the Type EP or Type KP thermoelement alloy crystal structure. **E839**

skin temperature, *n*—average temperature of a flat skin surface as measured from the *field of view* of an IR skin type thermometer, with an appropriate adjustments for skin emissivity. **E1965**

specific color phenomena, *n* **(using instrumental methods of evaluation):—**

blue—that temperature at which the intensity of 470 nm light reflected by the liquid crystal is maximum, symbolized as T°470.

green—that temperature at which the intensity of 520 nm light reflected by the liquid crystal is maximum, symbolized as T°520.

red—that temperature at which the intensity of 650 nm light reflected by the liquid crystal is maximum, symbolized as T°650. **E1061**

specific gravity, *n*—the ratio of the mass of a given volume of material at a stated temperature to the mass of an equal volume of gas-free distilled water at a stated temperature, expressed by

$$\text{Specific Gravity } x/x\ F\ (\text{or } y/y\ C) \qquad (7)$$

where *x* is usually 60 °F and *y* is usually 15.56 °C. **E126**

spectral emissivity—the ratio of the spectral radiance at a point on a particular specimen and in a particular direction from that point to that emitted by a blackbody at the same temperature. **E452**

spectral radiance—the power radiated by a specimen in a particular direction per unit time, per unit wavelength, per unit projected area of the specimen, and per unit solid angle. **E452**

staining—marking the surface of glass by diffusing the colorant into the glass surface. **E667**

start of blue (SB), *n*—that temperature at which the liquid crystal first begins to reflect blue light, which is defined as light having a wavelength of 491 nm. **E1061**

start of green (SG), *n*—that temperature at which the liquid crystal first begins to reflect green light, which is defined as light having a wavelength of 575 nm. **E1061**

start of red (SR), *n*—that temperature at which the liquid crystal first begins to reflect red light, which is defined as light having a wavelength of 675 nm. **E1061**

storage package—the smallest package intended by the manufacturer for long-term storage at the user's facility. **E825**

subject, *n*—a human whose temperature is measured. **E1965**

subnormal thermometer—a thermometer specifically designed for obtaining body temperatures below the "regular scale" range. **E667**

suitable packaging unit—the unit(s) of packaging to which a specific requirement of marking and labeling is logically applicable. It shall not be less than the smallest unit intended for sale by the manufacturer or distributor to the final user. **E825, E1104**

supercooled state, *n*—the meta-stable state of reference material in which the temperature of the liquid phase is below the freezing point. **E1502**

system, *n*—combination of an *IR thermometer* and an installed *probe cover.* **E1965**

target size, *n*—the diameter of a circle in the target plane of a radiation thermometer that is centered on its line of sight and contains 99 % of the input radiant power received by that instrument. **E1256**

temperature offset—the designed difference in predictive thermometer readings and water bath test temperatures. **E825**

temperature resolution, *n*—the minimum simulated or actual change in target temperature that gives a usable change in output or indication, or both. **E1256**

terminal block, *n*—a screw terminal device for connection of thermoelements and extension wires or the connection of extension wires to each other or to instruments. **E1350**

test difference, *n*—the apparent thermoelectric difference attributable to mated connectors observed by the test procedure of this specification. **E1684**

test specimen, *n*—a short length, at least 300 mm long, cut from the bulk material length. **E780**

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

DISCUSSION—In reporting the results, the value of the test temperature may be rounded off, provided the stated test temperature is within the bounds indicated in 10.10. **E207**

test thermocouple, *n*—a thermocouple that is to have its temperature-emf relationship determined by reference to a temperature standard. **E452**

thermal profile, *n*—temperatures at which specific color phenomena occur in a liquid crystal thermometer. **E1061**

thermocouple assembly—the cut-to-length, finished assembly consisting of thermocouple material with thermoelements having one end joined in a measuring junction. The assembly has the sheath closed at the measuring end and has a moisture seal at the reference junction end of the sheath. The assembly does not include a reference junction but may include a thermocouple connector. **E839**

thermocouple calibration point—a temperature, established by a standard, at which the emf developed by a thermocouple is determined. **E452**

thermocouple connector, *n*—as described in Specification E1129/E1129M, a quick-connect plug and jack using matching or compensating materials that have Seebeck coefficients like the extension wires or the thermoelements they connect. The thermocouple connector will match the Seebeck coefficient of the thermoelements over only a limited temperature range. **E1350**

thermocouple type, *n*—a nominal thermoelectric class of thermoelement materials that, used as a pair, have a standardized relationship and tolerance between relative Seebeck EMF and temperature, physical characteristics, and an assigned type letter designator and color code.

DISCUSSION—Letter designators and color codes are defined in the United States by ANSI/ASTM E230. Descriptions of letter designators and color codes may also be found in ASTM MNL-12.[7] **E1159**

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. **E644**

thermo-hydrometer, *n*—a glass hydrometer having a thermometer combined with a hydrometer in one instrument. **E126**

time constant, *n*—the 63.2 % response time of a sensor that exhibits a single-exponential response. **E879**

top of the hydrometer, *n*—the top of the finished instrument. **E100**

top of the thermometer, *n*—the top of the finished instrument. **E1**

total length, *n*—the distance from the bottom of the bulb to the top of the finished thermometer, including any special finish at the top. **E1**

total length, *n*—the overall length of the finished hydrometer. **E100**

total life—the time required for open circuit to occur in the test thermoelement. **E601**

transducer, *n*—a device that provides a measurable output (for example, resistance, emf, etc.) as a function of temperature. **E1112**

triangular magnifying lens—thermometer stem glass in which the numerals and graduations lie on surfaces that smoothly merge to form a lens. It is so named for its approximately triangular cross section. **E667**

true temperature, *n*—temperature attributed to a particular site of a *subject* or object of measurement and accepted as having a specified uncertainty. **E1965**

tympanic temperature, t_{ty}, *n*—temperature of either tympanic membrane as measured by a *contact thermometer.* **E1965**

type of thermocouple—the type of a thermocouple is represented by a letter designation as defined in accordance with Specification E230. **E220**

unadjusted mode, *n*—an output of *IR thermometer* that displays temperature measured and calculated from a *subject* or object, without any corrections for variations in *operating temperature*, subject temperature, emissivity, etc. **E1965**

undercool, *n*—the temperature depression below the freezing point of reference material in the supercooled state. **E1502**

verification, *n*—the process of testing a thermometer for compliance with specifications. **E77**

verification temperatures, *n*—the specified temperatures at which thermometers are tested for compliance with scale error limits. **E77**

visible start (VS), *n*—that temperature at which the liquid crystal first begins to reflect visible light. **E1061**

zero-power resistance, *n*—the dc resistance of a device, at a specified temperature, calculated for zero-power.

DISCUSSION—Accurate zero-power resistance is obtained by extrapolating to zero-power the resistance values obtained from measurements at three or more levels of power with the sensor immersed in a constant temperature medium. For the purpose of this specification, this is obtained from measurements at a single power level adjusted such that the power is not greater than one-fifth the product of the dissipation constant specified in Table 1 (see section 3.2.1 and section 7.3) and the appropriate tolerance requirement of Table 2. When making stability measurements, the power shall be kept constant. **E879**

[7] *Manual on the Use of Thermocouples in Temperature Measurement*, ASTM MNL-12, Fourth Edition, ASTM , April 1993. (Revision of STP 470B.)

APPENDIX

(Nonmandatory Information)

X1. THE INTERNATIONAL TEMPERATURE SCALE OF 1990 (ITS-90)

X1.1 *Principles of the ITS-90:*[6]

X1.1.1 ITS-90 extends from a lower limit of 0.65 K to the highest temperature measurable using the Planck radiation law.

X1.1.2 ITS-90 is divided into a number of ranges and subranges, each with its own definition of values of temperature.

X1.1.3 Several ranges or subranges overlap, resulting in differing definitions that have equal status at some temperatures. It is possible that the differing definitions could yield different numerical values of a temperature, but such differences are usually negligible.

X1.1.4 ITS-90 has been constructed so that at any given temperature its numerical value is close to the numerical value of the same thermodynamic temperature.

X1.2 *Definition of ITS-90:*

X1.2.1 The official text (definition) of ITS-90 is given in the reference cited in Footnote 5. An introductory note in the reference states:
"The official French text of the ITS-90 is published by the BIPM as part of the Procès-verbaux of the Comité International des Poids et Mesures (CIPM). However, the English version of the text reproduced here has been authorized by the Comité Consultatif de Thermométrie (CCT) and approved by the CIPM."

X1.2.2 From 0.65 K to 5.0 K values of temperature on the ITS-90 are defined by the relationship between temperature and the vapor pressure of either isotope of helium (mass 3 or 4).

X1.2.3 Between 3.0 K and 24.5561 K values of temperature ITS-90 are defined by means of a helium gas thermometer calibrated by measurements at three defining fixed points and by using specified interpolation procedures.

TABLE X1.1 Defining Fixed Points of the ITS-90

Material[A]	Equilibrium State[B]	Assigned Value of Temperature	
		T_{90} (K)	t_{90} (°C)
He	VP	3 to 5	–270.15 to –268.15
e-H_2	TP	13.8033	–259.3467
e-H_2 (or He)	VP (or GT)	≈17	≈–256.15
e-H_2 (or He)	VP (or GT)	≈20.3	≈–252.85
Ne	TP	24.5561	–248.5939
O_2	TP	54.3584	–218.7916
Ar	TP	83.8058	–189.3442
Hg	TP	234.3156	–38.8344
H_2O	TP	273.16	0.01
Ga	MP	302.9146	29.7646
In	FP	429.7485	156.5985
Sn	FP	505.078	231.928
Zn	FP	692.677	419.527
Al	FP	933.473	660.323
Ag	FP	1234.93	961.78
Au	FP	1337.33	1064.18
Cu	FP	1357.77	1084.62

[A] e-H_2 indicates equilibrium hydrogen, that is, hydrogen with the equilibrium distribution of its ortho and para forms at the corresponding temperatures. Normal hydrogen at room temperature contains 25 % para and 75 % ortho hydrogen. The isotopic composition of all materials is that naturally occurring.
[B] VP indicates vapor pressure point or equation; GT indicates gas thermometer point; TP indicates triple point; FP indicates freezing point; MP indicates melting point.

X1.2.4 Between 13.8033 K and 1234.93 K (961.78 °C) values of temperature on the ITS-90 are defined by means of platinum resistance thermometers meeting specified requirements. The thermometers are calibrated by measurements at specified sets of defining fixed points and by using specified interpolation procedures.

X1.2.5 Above 1234.93 K (961.78 °C) values of temperature on the ITS-90 are defined in terms of a defining fixed point and the Planck radiation law.