Designation: E77 – 14

Standard Test Method for Inspection and Verification of Thermometers[1]

This standard is issued under the fixed designation E77; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This test method covers visual and dimensional inspection and test for scale accuracy to be used in the verification of liquid-in-glass thermometers as specified in Specifications E1 and E2251. However, these procedures may be applied to other liquid-in-glass thermometers.[2]

NOTE 1—The use of NIST SP250-23[2] is recommended.

1.2 **Warning—**Mercury has been designated by EPA and many state agencies as a hazardous material that can cause central nervous system, kidney and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website-http://www.epa.gov/mercury/faq.htm - for additional information. Users should be aware that selling mercury and/or mercury containing products into your state may be prohibited by state law.-

1.3 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

E1 Specification for ASTM Liquid-in-Glass Thermometers

E344 Terminology Relating to Thermometry and Hydrometry

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

3. Terminology

3.1 *Definitions:*

3.1.1 The definitions given in Terminology E344 apply. Some that are considered essential to this standard are given below.

3.1.2 *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.

3.1.2.1 *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.

3.1.3 *complete-immersion thermometer, n—* a liquid-in-glass thermometer, not specified in ASTM documents, designed to indicate temperature correctly when the entire thermometer is exposed to the temperature being measured.

3.1.4 *partial-immersion thermometer, n—* a liquid-in-glass thermometer designed to indicate temperature correctly when the bulb and a specified part of the stem are exposed to the temperature being measured.

3.1.5 *total-immersion thermometer, n—*a liquid-in-glass thermometer designed to indicate temperature correctly when just that portion of the thermometer containing the liquid is exposed to the temperature being measured.

3.2 *Definitions of Terms Specific to This Standard:*

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

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

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[1] This test method is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.05 on Liquid-in-Glass Thermometers and Hydrometers.

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[2] "Liquid-in-Glass Thermometer Calibration Service," NIST Special Publication 250-23, 1988, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.

[3] 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.

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

3.2.4 Other descriptions of terms relating to thermometers are included in Sections 3 and 17 of Specification E1.

4. Significance and Use

4.1 The test method described in this standard will ensure that the thermometers listed in Specifications E1 and E2251 will indicate temperatures within the maximum scale errors listed, be compatible with the apparatus, and serve the purpose for which they were designed.

4.2 Thermometers that do not pass the visual and dimensional inspection tests may give erroneously high or low temperature readings, or may not fit into existing equipment used in ASTM methods. For accurate temperature measurements the scale readings of the thermometer should be verified as described in this test method.

5. Apparatus

5.1 *Graduated Metal Scales or Templates*—Maximum and minimum specified linear dimensions are measured with graduated metal sales and templates on which lines are ruled at suitable distances from reference points corresponding to the maximum and minimum values of the several specified dimensions.

5.2 *Micrometers and Ring Gages*—Specified diameters of ASTM thermometers are checked using micrometers, or more conveniently with ring gages consisting of metal plates in which holes have been formed corresponding to the maximum and minimum values of the several specified dimensions. The thickness of such gages should approximate the diameters of the holes to minimize errors resulting from the axis of the thermometer stem being other than normal to the plane of the gage. When specified, diameters may also be checked with conventional snap gages having plane parallel working faces.

5.3 *Comparators*—Comparators are required for verification of scale accuracy of liquid-in-glass thermometers. Suitable types are described in Appendix X1.

5.4 *Primary Standard Thermometer*—The primary standard thermometer in the range from −183 to 630 °C (−297 to 1166 °F) is the platinum-resistance thermometer. Temperatures are not measured directly with this instrument. Its electrical resistance is determined by comparison with a standard resistor, using a potentiometer, a Kelvin-type double bridge, or a Wheatstone bridge, (preferably of the Mueller type) or an AC resistance bridge. Temperatures may then be calculated using suitable resistance-temperature equations. In order that it shall be satisfactory for such use, the thermometer should meet the requirement that the ratio of resistances at the steam and ice points shall be greater than 1.3925. More complete information on the construction and use of primary standard thermometers may be obtained from NIST SP250-22.[4]

5.5 *Secondary Standard Thermometers*— Secondary standard thermometers are more suitable for routine work, and may be of various types as described below. They are simpler to use than a primary standard thermometer with its accessory equipment, the latter being capable of an order of precision and accuracy far in excess of that attainable with liquid-in-glass thermometers. The choice of a secondary standard will be governed by various factors. The following criteria should, in so far as possible, be satisfied: The standard should be a calibrated thermometer of equal or preferably higher sensitivity than the thermometer to be verified, and it should be capable of giving results of an equal or preferably higher order of accuracy and also of an equal or preferably higher order of reproducibility or precision. Scale corrections should always be applied in the use of these standards. Secondary standards may be of the following types.

5.5.1 *Direct-Reading Resistance Thermometers*—Direct-reading resistance thermometers are available commercially, are very convenient to use, and have the advantage over the primary type that temperature indications are given directly in the instrument reading. They should be completely recalibrated every 6 to 12 months, depending upon the temperatures of usage. Ice points should be taken every 3 months.

5.5.2 *Liquid-in-Glass Thermometers*—Liquid-in-glass thermometers, when used as secondary standards, may be classified into two groups, those intended for testing general purpose total or partial-immersion thermometers, and those for testing special use partial-immersion thermometers.

5.5.2.1 *Total-Immersion Thermometers*—In the case of general purpose total-immersion thermometers, the sensitivity of the thermometers to be tested will govern the choice of standard. For thermometers graduated in 1, 2, or 5° divisions, a set of well-made thermometers will be adequate when calibrated and used with applicable corrections. For fractionally graduated thermometers a calibrated set of the following thermometers is recommended. Specifications for these ASTM Precision Thermometers appear in Specification E1.

ASTM Thermometer Number	Range	Celsius	Divisions	Length, mm
62C	−38 to	+2°C	0.1°C	380
63C	−8 to	+32°C	0.1°C	380
64C	25 to	55°C	0.1°C	380
65C	50 to	80°C	0.1°C	380
66C	75 to	105°C	0.1°C	380
67C	95 to	155°C	0.2°C	380
68C	145 to	205°C	0.2°C	380
69C	195 to	305°C	0.5°C	380
70C	295 to	405°C	0.5°C	380

ASTM Thermometer Number	Range	Fahrenheit	Divisions	Length, mm
62F	−36 to	+35°F	0.2°F	380
63F	18 to	89°F	0.2°F	380
64F	77 to	131°F	0.2°F	380
65F	122 to	176°F	0.2°F	380
66F	167 to	221°F	0.2°F	380
67F	203 to	311°F	0.5°F	380
68F	293 to	401°F	0.5°F	380
69F	383 to	581°F	1.0°F	380
70F	563 to	761°F	1.0°F	380

[4] "Platinum Resistance Thermometer Calibrations," NIST Special Publication 250-22, Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402-9325.

The foregoing set is calibrated for total immersion. With the exception of the first two, each thermometer is provided with an auxiliary scale including 0 °C (32 °F), thus providing means for checking at a fixed point, which should be done each time the thermometer is used. The change in ice-point reading should then be applied to all readings. It is only necessary to have a liquid-in-glass thermometer completely calibrated one time. Recalibration is performed as described in 6.3.8.

5.5.2.2 *Partial-Immersion Thermometers—* General purpose partial-immersion thermometers, as commonly listed in manufacturers' catalogs according to their own specifications, are normally bought and sold without specification of the temperatures of the emergent column for the various temperature indications of the thermometers. In such cases, verification is usually carried out for the emergent column temperatures prevailing with the verification equipment being employed.

5.5.2.3 *Special Use Partial-Immersion Thermometers—* Special use partial-immersion thermometers, such as those covered in Specification E1, have specified emergent mercury columns or stem temperatures. These thermometers can be used as standards to calibrate other thermometers similar in all details of construction above the immersion point, but may differ below the immersion point to the extent of including an auxiliary ice point scale.

5.6 *Engraving Date on ASTM Thermometers—*If a thermometer's specification was changed, the year that it was changed is engraved on the back of the thermometer after the ASTM designation. For example, "12C-98."

6. Procedure

6.1 *Visual Inspection:*

6.1.1 *Gas Bubbles and Separations—*Gas bubbles are readily detected and are more likely to occur in shipment than during service. No method has been discovered that will entirely prevent such displacement of the gas. If bubbles are observed in the bulb, they can generally be removed by cooling the bulb with dry ice or other convenient coolant until all the liquid is drawn into the bulb. Gentle tapping of the thermometer while held upright will cause the bubbles to rise to the surface. It is very important that, if the bulb is cooled in this process below the freezing point of the liquid, care should be exercised to warm the stem sufficiently during the melting process so that no solidification occurs in the stem; otherwise the bulb may burst or the capillary may split internally because of the expansion forces generated in the bulb.

6.1.1.1 If a mercury separation is observed in the stem, several different ways are suggested for joining the columns, depending on the construction of the thermometer and the type of separation. If a small portion of the liquid has separated at the top of the column and the thermometer is provided with an expansion chamber, the liquid usually can be joined by carefully and slowly heating the bulb until the separated portion is driven into the expansion chamber. Never heat the bulb in an open flame. When the column itself follows into the chamber, the separated portion usually will join onto the main column. A slight tapping of the thermometer against the palm of the hand will facilitate this joining. This method should not be employed for high-temperature thermometers (above 260 °C or 500 °F), because the heating of the bulb, which is necessary to drive the liquid into the expansion chamber, may overheat the glass and either break the bulb, because of the pressure of the gas, or destroy the accuracy of the thermometer by expanding the bulb. Thermometers that have a contraction chamber below the lowest graduation are likely to develop separations either in the chamber or above it. It is frequently possible to join such separations by cooling the thermometer so that the separated portion as well as the main column both stand in the chamber. Tapping the tube against the hand or the bulb on a soft spongy material, such as a rubber stopper, usually will bring the liquid together. For more stubborn separations it may be necessary to cool the bulb in dry ice to a point low enough to bring all of the liquid into the bulb itself. By softly tapping on a soft spongy material or against the hand it usually is possible to bring the liquid together in the bulb. The bulb should be allowed to warm up slowly. The liquid should emerge into the bore with no separation.

6.1.1.2 In organic-liquid-filled thermometers distillation may occur, with subsequent condensation of the colorless parent liquid in the upper part of the thermometer. Such thermometers should always be inspected for these separations, which can be repaired by the procedures described above. If the thermometer has an expansion chamber that is observed to be filled with liquid, the column can be reunited by very careful heating of the chamber to drive the liquid into the bore where it can be rejoined to the main body as described above.

6.1.1.3 Organic liquids as used in thermometers, in contrast to mercury, wet the glass. Sufficient time should always be allowed for drainage to occur, particularly when using or verifying such thermometers below 0 °C (32 °F). It is frequently a good practice to immerse only the bulb of the thermometer. This keeps the viscosity of the liquid in the capillary low and aids in hastening drainage.

6.1.2 *Globules of Liquid—*Globules of liquid in the stem, which result from mechanical separation, can normally be rejoined by heating the bulb until the liquid column merges with the globules. If such globules appear to unite and then reappear on cooling the bulb, they are indicative of oxidation of the mercury or the presence of obstructions in the bore, and should result in rejection of the thermometer.

6.1.3 *Foreign Matter—*Foreign matter in the bore can sometimes be detected with the unaided eye, but it is generally convenient to use a magnifying glass of low power for this examination. A magnifier of 10× is recommended for visual examination. The most common types of foreign matter which should be cause for rejection are glass chips, particles of dirt or lint, oxide of mercury (either red, yellow, or black), products of glass weathering commonly called white deposit, and stones or iron spots traceable to faulty glass fabrication.

6.1.3.1 Where a specific gas is specified to be used as filling above the liquid, any other gas present may be treated as foreign matter. The most common example is the use of air instead of nitrogen in mercury-in-glass thermometers, which may have been introduced by accident or in violation of the specifications. The presence of air can readily be detected by