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Designation: E2251 – 11

StandardSpecification for Liquid-in-Glass ASTM Thermometers with Low-Hazard Precision Liquids[1]

This standard is issued under the fixed designation E2251; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 The purpose of this standard is to specify liquid-in-glass ASTM thermometers using low hazard thermometric liquids defined in this standard.

1.2 This standard specifies liquid-in-glass thermometers graduated in degrees Celsius or degrees Fahrenheit that are frequently identified and used in methods under the jurisdiction of the various technical committees within ASTM. The current approved thermometers are listed in Table 1.

1.3 The technical requirements for the thermometric liquids used in the thermometers in Table 1 are specified in Annex A1. Tests for conformity to the technical requirements are also found in Annex A1.

NOTE 1—It has been found by experience that ASTM Thermometers, although developed in general for specific tests, may also be found suitable for other applications, thus precluding the need for new thermometer specifications differing in only minor features. However, it is suggested that technical committees contact E20.05 before choosing a currently designated thermometer for a new method to be sure the thermometer will be suitable for the intended application.

1.4 For full rationale, see Appendix X1.

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

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

E344 Terminology Relating to Thermometry and Hydrometry

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

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E344 apply.

3.2 *Definitions of Terms Specific to This Standard:*

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

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

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

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

3.2.5 *faden thermometer, n*—a thermometer with a long, thin bulb used to determine emergent stem temperatures.

3.2.6 *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).

3.2.7 *low-hazard liquid, n*—a liquid that is biodegradable, non-hazardous and considered non-toxic in thermometer quantities.

NOTE 2—It is the responsibility of the manufacturer to determine the suitability of a liquid for this standard. In marking the thermometer with the ASTM designation the manufacturer is confirming that the liquid in the thermometer is non-hazardous as defined by current OSHA (Occupational Safety and Health Administration) standards and non-toxic in thermometer quantities per current definitions of the United States Environmental Protection Agency.

3.2.8 *thermometric liquid, n*—the liquid in a liquid-in-glass thermometer that indicates the value of temperature.

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

[1] This specification 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] 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.

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3.2.10 *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.

3.3 Other terms may be found in the Terminology sections of Specification E1 and Test Method E77.

4. Specifications

4.1 The individual thermometers shall conform to the detailed specifications given in Table 1, the general requirements specified in Sections 5 – 15, and Annex A1 and Annex A2.

NOTE 3—Thermometers manufactured to previous revisions of this standard shall retain the same ASTM status as those meeting current specifications.

NOTE 4—The encapsulation (jacketing) of the glass of liquid-in-glass thermometers with polyflourinated hydrocarbons will change their performance and physical characteristics, including, but not limited to, response time, accuracy, and physical dimensions. Therefore, under no circumstances should an encapsulated or otherwise modified ASTM thermometer be used in performing tests that specify the use of an ASTM thermometer.

5. Type

5.1 Each thermometer in Table 1 shall be of the liquid-in-glass type filled with a low hazard thermometric liquid that meets the specifications in Annex A1. The gas filling above the liquid shall be nitrogen or other suitable inert gas. The filling gas shall be chosen to have very low solubility in the thermometric fluid.

6. Stem

6.1 *Stem*—The stem shall be made of suitable thermometer tubing and shall have a plain front and enamel back.

6.2 *Top Finish*—The top of all thermometers specified in Table 1 shall have a plain rounded finish, except the following, which shall have the top finish indicated below:

6.2.1 *Special Finish:*

6.2.1.1 Any finish suitable for assembly in a standard 304.8-mm (12-in.) non-sparking metal armor with open face; in a cup case assembly; or in a flushing case assembly as defined in standards the thermometers are used in:

Thermometers S58C, S58F, S59C, S59F, S130C, S130F

7. Bulb

7.1 The bulb shall be made of glass having a viscosity of at least $10^{14.6}$ poises at 490°C (914°F) and at least $10^{13.4}$ poises at 520°C (968°F).

NOTE 5—Thermometers made with bulb glasses having properties close to these minimum requirements should not be subjected to temperatures above 405°C (760°F) or be continuously exposed to temperatures above 370°C (700°F).

8. Capillary Clearances

8.1 The following distances between graduations and the bulb, and between graduations and enlargements in the capillary, are minimum limits acceptable for thermometers in this standard.

NOTE 6—In order for a thermometer to be usable over its entire graduated range, graduation marks must not be placed too close to any enlargement in the capillary. Insufficient immersion of the thermometric liquid in the main bulb or capillary enlargement, graduation marks placed over parts of the capillary that have been changed by manufacturing operations, or graduations so close to the top of the thermometer that excessive gas pressure results when the thermometric liquid is raised to this level, may lead to appreciable errors.

8.1.1 A 13-mm length of unchanged capillary between the bulb and the immersion line or lowest graduation, if the graduation is not above 100°C (212°F); a 30-mm length if the graduation is above 100°C (212°F).

8.1.2 A 5-mm length of unchanged capillary between an enlargement and the graduation next below, except at the top of the thermometer.

8.1.3 A 10-mm length of unchanged capillary between an enlargement, other than the bulb, and the immersion line or the graduation next above, if the graduation is not above 100°C (212°F); a 30-mm length if the graduation is above 100°C (212°F).

8.1.4 A 10-mm length of unchanged capillary above the highest graduation, if there is an expansion chamber at the top of the thermometer; a 30-mm length if there is no expansion chamber. For the purposes of this requirement, "an expansion chamber" is interpreted as an enlargement at the top end of the capillary bore that shall have a capacity equivalent to not less than 20 mm of unchanged capillary.

8.2 Due to a change in the methods used for scale placement, it is possible to manufacture thermometers that comply with the specifications given in Table 1, but not meet the requirements for capillary clearances given above. In any case, the distances given in this section are the governing factor. Under no circumstances shall the scales on thermometers be placed closer than these minimum distances.

9. Graduations and Inscriptions

9.1 All graduation lines, figures, and letters shall be clearly defined, suitably colored, and permanent. The width and the sharpness of the graduation lines shall be designed in accordance with necessary space between the graduations and the desired accuracy of interpolation. The middle of the graduation line shall be accurately determinable.

9.1.1 A suitably etched thermometer with the etched lines and figures filled with a suitable colorant shall be considered permanently marked provided it passes the test for permanency of pigment in Test Method E77.

9.2 *Graduation Lines*—All graduation lines shall be straight, of uniform width, and perpendicular to the axis of the thermometer. The width of the graduation lines shall be as follows:

9.2.1 *Group 1*—Maximum line width 0.10 mm; for thermometers that may read to fractions of a division, often with magnifying aids:

Thermometers S56C, S56F, S62C, S62F, S63C, S63F, S64C, S64F, S65C, S65F, S66C, S66F, S67C, S67F, S91C, S116C, S117C, S120C

9.2.2 *Group 2*—Maximum line width 0.15 mm; for thermometers that may be read to the nearest half division or where the congestion of scale dictates the use of a scale to moderate fineness:

Thermometers S5C, S5F, S12C, S12F, S15C, S15F, S18C, S18F, S22C, S22F

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9.2.3 *Group 3*—Maximum line width 0.20 mm; for thermometers with more open scales, usually read to the nearest division, often times under adverse conditions where a bold graduation is therefore desired:

Thermometers S58C, S58F, S59C, S59F, S130C, S130F

9.3 *Immersion Line*—On partial immersion thermometers an immersion line shall be permanently marked on the front of the thermometer at the distance above the bottom of the bulb as specified in Table 1 within a tolerance of ±0.5 mm. The immersion inscription shall be written in capital letters and abbreviated (for example, 76 mm immersion shall be written 76 MM IMM.)

9.4 *Terminal Numbers*—The terminal number shall be in full when there are one or more numbered graduations between it and the next full number. This rule need not necessarily be followed for:

9.4.1 *Precision Thermometers:*

S65F, S66F, S67C, and S67F

9.5 *Scale Below Zero*—When a scale extends both above and below 0°C or 0°F, the two parts of the scale shall be differentiated by some means. Examples of suitable means are:

9.5.1 Different colorants for the graduations for the two parts of the scale,

9.5.2 Different style of numerical characters for the two parts of the scale, and

9.5.3 Use of minus signs before appropriate numbers below 0°C or 0°F.

10. Special Inscription

10.1 The special inscription specified in Table 1 shall be marked on the thermometer in capital letters and Arabic numbers without the use of periods. Include year of current revision in the ASTM designation (for example ASTM S56C-03).

10.1.1 Each thermometer shall be permanently marked with a unique serial number and the manufacturer's tradename or mark.

10.1.2 Each thermometer shall have the average coefficient of thermal expansion of the liquid permanently marked.

10.1.3 When the length of the thermometer permits, the words "TOTAL IMMERSION" may also be inscribed on the back of thermometers calibrated for total immersion.

11. Permanency of Pigment

11.1 The test for permanency of pigment shall be performed on any convenient portion of the scale section of the thermometer. The pigment shall not chalk, burn out, or loosen as a result of this test (see Test Method E77).

12. Bulb Stability

12.1 No test for bulb stability is necessary for any thermometers currently in this standard. However, should there be in the future, the bulb stability test as found in Specification E1 shall be used.

13. Scale Error

13.1 Thermometers shall be verified and calibrated at the temperatures specified in Table 4. Partial immersion thermometers shall be calibrated for the emergent stem temperatures specified in Table 4 using faden thermometers.

13.1.1 At the time of purchase, the scale errors must be within the maximum scale error found in Table 1. The indications of many high temperature and fractionally graduated thermometers may change with time and continued use, due to minute changes in bulb volume. Periodic verification of these thermometers either over the entire scale or reverification at the reference temperature (ice point or steam point), in accordance with procedures set forth in Test Method E77, is recommended.

13.2 Due to the application requirements for range and construction of the following thermometer(s) do not have reference points such as ice and steam points:

S91C

14. Case and Instructions

14.1 Each thermometer shall be supplied in a suitable case on which shall appear the following marking (except when a transparent case is used): the letters "ASTM," the thermometer number (S59C, S59F, etc.), and the temperature range.

14.2 Each thermometer shall be supplied with suitable user instructions. See Appendix X2 for Sample User Instructions.

15. Methods of Verification and Calibration

15.1 Thermometers shall be verified and calibrated at the specified immersion in accordance with Test Method E77. For partial immersion thermometers careful consideration to emergent stem temperatures shall be observed.

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TABLE 1 Specification for E2251 ASTM Thermometers

All dimensions are in millimeters.
See Table 4 for Verification and Calibration Temperatures.

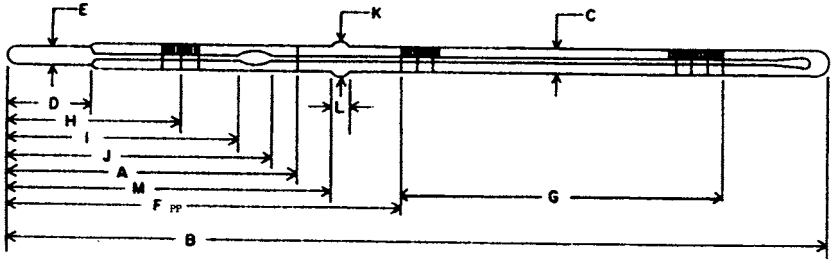

FIG A. General Reference Figure for Table 1
(Specific figures associated with individual thermometers are found at the end of Table 4)

Explanatory Notes for Table 1 (numbers correspond to those found in Table 1 of Specification E1 whenever possible):

[A] An expansion chamber is provided for relief of gas pressure to avoid distortion of the bulb at higher temperatures. It is not for the purpose of joining thermometric liquid separations and under no circumstances should the thermometer be heated above the highest temperature reading.

[G] The test temperatures shall be indicated by an arrow whether the graduation corresponding to that point is numbered or not.

[M] For kinematic viscosity thermometers, the ice-point reading shall be taken within 1 h after being at the test temperature for not less than 3 min. The ice-point reading shall be expressed to the nearest 0.01°C or 0.02°F and applied as explained in Test Method E77, Section 13.

[O] Capillary clearances must conform to Section 8.

[Y] Over any interval of 2°C the change in claibration correction shall not exceed 0.02°C.

[Z] Over any interval of 4°F the change in claibration correction shall not exceed 0.05°F.

[AA] Special finish, see 6.2.1.

[BB] The bulb diameter shall not be more than 0.5 mm greater than the stem.

[FF] For Fahrenheit thermometers, dimension G (length of graduated portion) shall be measured as the length of graduated portion corresponding to the nominal Celsius range.

[OO] Bulb length as necessary for the thermometric liquid and meeting capillary clearances found in Section 8.

[PP] Distance "F" may be to top temperature for thermometers. See individual thermometer reference figure numbers.

[RR] Contraction chamber necessary for the thermometric liquid and conforming to capillary clearances found in Section 8.

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TABLE 1 *Continued*

ASTM No.	S5C-11	S5F-11[FF]	S12C-03	S12F-03[FF]	S15C-11	S15F-11[FF]	S18C-11	S18F-11[FF]	S22C-11	S22F-11[FF]
IP No.										
Name	Cloud and Pour		Density-Wide Range		Low Softening Point		Reid Vapor Point		Oxidation Stability	
Reference Fig. No.	5		2		2		6		6	
Range	–38 to 50°C	–36 to 120°F	–20 to 102°C	–5 to 215°F	–2 to +80°C	30 to +180°F	34 to +42°C 37.8°C[G]	94 to +108°F 100°F[G]	95 to 103°C 98.9 and 100°C[G]	204 to 218°F 210°F[G]
For test at										
A Immersion, mm	108		TOTAL		TOTAL		TOTAL		TOTAL	
Graduations:										
Subdivisions	1°C	2°F	0.2°C	0.5°F	0.2°C	0.5°F	0.1°C	0.2°F	0.1°C	0.2°F
Long lines at each	5°C	10°F	1°C	1°F	1°C	1°F	0.5°C	1°F	0.5°C	1°F
Numbers at each	10°C	20°F	2°C	5°F	2°C	5°F	1°C	2°F	1°C	2°F
Scale error, max	0.5°C	1°F	0.15°C	0.25°F	0.2°C	0.4°F	0.1°C	0.2°F	0.1°C	0.2°F
Special inscription	ASTM S5C-11 or S5F-11 108 MM IMM		ASTM S12C-03 or S12F-03		ASTM S15C-11 or S15F-11		ASTM S18C-11 or S18F-11		ASTM S22C-11 or S22F-11	
Expansion chamber:										
Permit heating to	70°C[A]	158°F[A]	130°C[A]	266°F[A]	100°C[A]	212°F[A]	70°C[A]	158°F[A]	125°C[A]	257°F[A]
B Total length, mm	254 to 264		435 to 445		395 to 400		295 to 305		295 to 305	
C Stem OD, mm	6.0 to 7.0		6.0 to 8.0		6.0 to 7.0		6.0 to 7.0		6.0 to 7.0	
D Bulb length, mm	[OO]		[OO]		[OO]		[OO]		[OO]	
E Bulb OD, mm	bulb size [ngt]stem size		not > stem		bulb size [ngt]stem size		bulb size [ngt]stem size		bulb size [ngt]stem size	
Scale location:										
Bottom of bulb to line at	50°C	120°F	102°C	215°F	80°C	180°F	42°C	108°F	103°C	218°F
F Distance, mm	195 to 205		370 to 385		328 to 343		210 to 222		210 to 222	
G Length of graduated portion, mm	65 to 85[O]		305 to 350[O]		245 to 276[O]		60 to 90[O]		60 to 90[O]	
Ice-point scale:										
Range										
H Bottom of bulb to ice-point, mm										
Contraction chamber:							[RR]		[RR]	
I Distance to bottom, min, mm							[RR]		[RR]	
J Distance to top, max, mm										
Stem enlargement:										
K OD, mm							8 to 9		8 to 9	
L Length, mm							4 to 7		4 to 7	
M Distance to bottom, mm							112 to 116		112 to 116	

[A] An expansion chamber is provided for relief of gas pressure to avoid distortion of the bulb at higher temperatures. It is not for the purpose of joining thermometric liquid separations and under no circumstances should the thermometer be heated above the highest temperature reading.
[G] The test temperatures shall be indicated by an arrow whether the graduation corresponding to that point is numbered or not.
[O] Capillary clearances shall conform to Section 8.
[FF] For Fahrenheit thermometers, dimension G (length of graduated portion) shall be measured as the length of graduated portion corresponding to the nominal Celsius range.
[OO] Bulb length as necessary for the thermometric liquid and meeting capillary clearances found in Section 8.
[RR] Contraction chamber necessary for the thermometric liquid and conforming to capillary clearances found in Section 8.

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TABLE 1 *Continued*

ASTM No.	S56C-03	S56F-03[FF]	S58C-11	S58F-11[FF]	S59C-03	S59F-03[FF]	S62C-03	S62F-03[FF]	S63C-03	S63F-03[FF]
IP No.										
Name	Bomb Calorimeter		Tank		Tank		Precision		Precision	
Reference Fig. No.	4		2[AA]		2[AA]		2		2	
Range	19 to 35°C	66 to 95°F	-34 to +49°C	-30 to +120°F	−18 to 82°C	0 to 180°F	−38 to +2°C	−36 to 35°F	−8 to 32°C	18 to 89°F
For test at										
A Immersion, mm	TOTAL		TOTAL		TOTAL		TOTAL		TOTAL	
Graduations:										
Subdivisions	0.02°C	0.05°F	0.5°C	1°F	0.5°C	1°F	0.1°C	0.2°F	0.1°C	0.2°F
Long lines at each	0.1°C	0.1 and 0.5°F	1°C	5°F	1°C	5°F	0.5°C	1°F	0.5°C	1°F
Numbers at each	0.2°C	1°F	5°C	10°F	5°C	10°F	1°C	2°F	1°C	2°F
Scale error, max	0.10°C[Y]	0.20°F[Z]	0.3°C	0.5°F	0.3°C	0.5°F	0.1°C	0.2°F	0.1°C	0.2°F
Special inscription	ASTM S56C-03 or S56F-03		ASTM S58C-11 or S58F-11		ASTM S59C-03 or S59F-03		ASTM S62C-03 or S62F-03		ASTM S63C-03 or S63F-03	
Expansion chamber:										
Permit heating to	45°C[A]	113°F[A]	100°C[A]	212°F[A]	100°C[A]	212°F[A]	55°C [A]	131°F[A]	55°C[A]	131°F[A]
B Total length, mm	610 to 622		300 to 305		300 to 305		401 to 411		401 to 411	
C Stem OD, mm	7.0 to 8.0		6.0 to 7.0		6.0 to 7.0		7.0 to 8.0		7.0 to 8.0	
D Bulb length, mm	[OO]		[OO]		[OO]		[OO]		[OO]	
E Bulb OD, mm	[BB]		bulb size [ngt]stem size		not > stem		not > stem		not > stem	
Scale location:										
Bottom of bulb to line at	35°C	95°F	49°C	120°F	82°C	180°F	0°C	32°F	32°C	89°F
F Distance, mm	510 to 550		245 to 260		245 to 260		306 to 324		319 to 344	
G Length of graduated portion, mm	323 to 385[O]		155 to 185[O]		165 to 195[O]		239 to 283[O]		239 to 289[O]	
Ice-point scale:										
Range										
H Bottom of bulb to ice-point, mm										
Contraction chamber:										
I Distance to bottom, min, mm	[O]									
J Distance to top, max, mm	110									
Stem enlargement:										
K OD, mm										
L Length, mm										
M Distance to bottom, mm										

[A] An expansion chamber is provided for relief of gas pressure to avoid distortion of the bulb at higher temperatures. It is not for the purpose of joining thermometric liquid separations and under no circumstances should the thermometer be heated above the highest temperature reading.
[O] Capillary clearances shall conform to Section 8.
[Y] Over any interval of 2°C the change in calibration correction shall not exceed 0.02°C.
[Z] Over any interval of 4°F the change in calibration correction shall not exceed 0.05°F.
[AA] Special finish, see 6.2.1.
[BB] The bulb diameter shall not be more than 0.5 mm greater than the stem.
[FF] For Fahrenheit thermometers, dimension G (length of graduated portion) shall be measured as the length of graduated portion corresponding to the nominal Celsius range.
[OO] Bulb length as necessary for the thermometric liquid and meeting capillary clearances found in Section 8.

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