Designation: E100 – 17

Standard Specification for ASTM Hydrometers[1]

This standard is issued under the fixed designation E100; 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 specification covers glass hydrometers of various scale graduation systems, as required by the ASTM Test Methods in which they are used.

1.2 *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 limitations prior to use.*

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)

D3290 Specification for Bond and Ledger Papers for Permanent Records (Withdrawn 2010)[3]

E1 Specification for ASTM Liquid-in-Glass Thermometers

E77 Test Method for Inspection and Verification of Thermometers

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

E344 Terminology Relating to Thermometry and Hydrometry

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

E2877 Guide for Digital Contact Thermometers

2.2 *Other Standards:*

ISO 1768:1975 Glass Hydrometers—Conventional Value for the Thermal Cubic Expansion Coefficient (for Use in the Preparation of Measurement Tables for Liquids)

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *ledger paper, n*—a paper characterized by strength, high tearing resistance, eraseability, water resistance, ink receptivity, uniformity of surface, and smoothness.

3.2.1.1 *Discussion*—Originally, ledger paper was used especially for pen and ink records. Most ledger papers are surface sized, frequently subjected to appreciable wear, and shall have a high degree of permanence and durability.

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

3.2.3 *relative density (formerly specific gravity), n*—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 the same or different temperature. Both reference temperatures shall be explicitly stated.

3.2.3.1 *Discussion*—Common reference temperatures include 60°F/60°F, 20°C/20°C, 20°C/4°C. The historic term specific gravity may still be found.

3.2.3.2 *Discussion*—The reference temperatures for ASTM hydrometers and thermohydrometers are found in Table 1 under the heading "standard temperature".

3.2.4 *specific gravity, n*—an historic term, replaced by *relative density*.

3.2.4.1 *Discussion*—hydrometers manufactured to this standard may be marked sp. gr., rel. density, or with both designations. The two terms are both equally acceptable in this standard and are used interchangeably.

3.2.5 *thermohydrometer, n*—glass hydrometer having an integral thermometer.

3.2.6 *top of the hydrometer, n*—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.

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

3.2.7 *total length, n*—overall length of the finished instrument.

4. Specifications

4.1 Individual hydrometers shall conform to the detailed specifications in Table 1 and to the general requirements specified in Sections 5 – 15.

4.2 Hydrometers shall be subjected to the initial calibration criteria found in Section 14, the inspection criteria found in Section 16, and the calibration and verification criteria found in Section 17.

4.3 Hydrometers manufactured to previous revisions of this specification shall retain the same ASTM status as those meeting current specifications.

4.4 At the time of purchase, scale errors shall be within the maximum scale error found in Table 1.

NOTE 1—**Caution**—Users should be aware that both temperature and density indications of thermohydrometers may change with rough handling, shock, exposure to aggressive liquids, and thermal cycling, among other factors. Consequently, test results and performance obtained at the time of manufacture may not necessarily apply throughout an extended period of use. Periodic calibration or verification of these instruments, in accordance with procedures set forth in Test Method E126 (for the hydrometer), or Test Method E77 (for the integral thermometer), is recommended

5. Type

5.1 Hydrometers shall be of the constant-mass, variable-displacement type. Hydrometers shall be made of glass, except for the scale, ballast, and the thermometric liquid of thermohydrometers.

5.2 The outer surface of the stem and body shall be symmetrical about the vertical axis. There shall be no uneven or unnecessary thickening of the walls, and no abrupt changes or constrictions that would hinder thorough cleaning or tend to trap air bubbles when the instrument is immersed.

5.3 The hydrometer shall always float with its axis vertical in liquids for which it is intended.

5.4 The hydrometer shall be thoroughly dry on the inside when sealed. The top of the stem shall be neatly rounded without unnecessary thickening.

5.5 The glass shall be smooth, transparent, and free of bubbles, cracks, strain patterns, or other imperfections that might interfere with the use of the hydrometer. The glass shall adequately resist the reaction of chemical agents to which hydrometers may be exposed and shall have suitable thermal properties to permit its use over the range of temperatures to which it may be subjected. In general, glasses suitable for constructing the bulbs of thermometers are satisfactory for hydrometers.

5.6 These hydrometers and thermohydrometers shall be fabricated from soda-lime glass tubing having a thermal cubical expansion coefficient of (25 +/- 2) x 10^{-6} per °C.

NOTE 2—The value of the thermal cubical expansion coefficient given above is consistent with the conventional value given in ISO 1768:1975.

6. Body

6.1 The preferred shapes for the bodies of hydrometers are shown in Figs. 1 and 2.

7. Ballast

7.1 Material used for ballast shall be secured to the lower part of the body, and no loose material of any sort may be inside a hydrometer. When cement is used to hold the ballast securely in place, this cement shall not soften below 105°C (221°F).

7.2 A solid material, such a shot, may be placed in a small bulb below the main bulb of the hydrometer and then melted or secured by cement.

7.3 If steel shot is used and sealed with wax, the wax shall not soften below 105°C (221°F).

7.4 Mercury shall not be used as ballast material in plain form hydrometers.

8. Stem

8.1 The stem shall be uniform in cross section, with no perceptible irregularities. It shall extend at least 15 mm above the top graduation and remain cylindrical for at least 3 mm below the lowest graduation.

9. Scale

9.1 The material for the scale is not specified. However, if paper is used, it shall only be ledger paper, meeting the specifications in Specification D3290. The scale may be anchored by a design which prevents it from moving; otherwise, it shall be fixed in place with cement that will not soften below 105°C (221°F) and will not deteriorate with time. The paper shall show no evidence of scorching or charring when received or after use at 105°C (221°F). The scale shall be straight and without twist.

10. Markings

10.1 Graduation lines and inscriptions shall be in a permanent black marking material, such as India ink.

10.2 All graduation lines shall be straight, fine lines not exceeding one fifth of the graduation interval in thickness, and in no case more than 0.2 mm. The lines shall be perpendicular to the vertical axis of the hydrometer. The lengths of main division lines, subdivision lines, and intermediate lines, if used, shall be so chosen as to facilitate readings. The shortest lines shall be at least 2 mm long.

10.3 All numbers on API hydrometers shall be complete. The numbers for the 0.050 graduation lines on relative density (specific gravity) and density hydrometers shall include the values for the first three decimal places, for example: 0.750, 0.900, 1.100; the other numbered lines may be abbreviated.

10.4 Relative density (specific gravity) hydrometers may be marked sp. gr., rel. density, or with both designations. The two terms are both acceptable in this standard and are used interchangeably.

TABLE 1 Specifications for ASTM Hydrometers

	API Gravity Hydrometers		Relative Density (Specific Gravity) Hydrometers		Relative Density (Specific Gravity) Hydrometers	
	For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)				For General Use	
	ASTM Hydrometer No.	Nominal API Gravity Range, deg	ASTM Hydrometer No.	Nominal Rel. Density (Sp. Gr.) Range	ASTM Hydrometer No.	Nominal Rel. Density (Sp. Gr.) Range
	1H-62	−1 to + 11	82H-62	0.650 to 0.700	For Alcohols[A]	
	2H-62	9 to 21	83H-62	0.700 to 0.750	98H-62	0.950 to 1.000
	3H-62	19 to 31	84H-61	0.750 to 0.800	For Heavy Liquids[A]	
	4H-62	29 to 41	85H-62	0.800 to 0.850	111H-62	1.000 to 1.050
	5H-62	39 to 51	86H-62	0.850 to 0.900	112H-62	1.050 to 1.100
	6H-62	49 to 61	87H-62	0.900 to 0.950	113H-62	1.100 to 1.150
	7H-62	59 to 71	88H-62	0.950 to 1.000	114H-62	1.150 to 1.200
	8H-62	69 to 81	89H-62	1.000 to 1.050	115H-62	1.200 to 1.250
	9H-62	79 to 91	90H-62	1.050 to 1.100	116H-62	1.250 to 1.300
	10H-62	89 to 101			117H-62	1.300 to 1.350
	11H-03	37 to 49			118H-62	1.350 to 1.400
	12H-03	64 to 76			119H-62	1.400 to 1.450
					120H-62	1.450 to 1.500
Standard temperature, °F	60		60/60		60/60	
Subdivisions	0.1° API		0.0005		0.0005	
Intermediate lines at	0.5° API		0.001		0.001	
Main (numbered) lines at	1.0° API		0.005		0.005	
Scale error at any point not to exceed	0.1° API		0.0005		0.0005	
Total length, mm	325 to 335		325 to 335		325 to 335	
Length of nominal scale, mm	125 to 145		125 to 145		125 to 145	
Scale extension beyond nominal range limits, max	0.2°		0.0025		0.0025	
Body diameter, mm	23 to 27		23 to 27		23 to 27	
Stem diameter min, mm	4.0		5.0		4.0	

	API Gravity Hydrometers			
	For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)			
	ASTM Hydrometer No.	Nominal API Gravity Range, deg	ASTM Hydrometer No.	Nominal API Gravity Range, deg
	21H-62	0 to 6	31H-62	50 to 56
	22H-62	5 to 11	32H-62	55 to 61
	23H-62	10 to 16	33H-62	60 to 66
	24H-62	15 to 21	34H-62	65 to 71
	25H-62	20 to 26	35H-62	70 to 76
	26H-62	25 to 31	36H-62	75 to 81
	27H-62	30 to 36	37H-62	80 to 86
	28H-62	35 to 41	38H-62	85 to 91
	29H-62	40 to 46	39H-62	90 to 96
	30H-62	45 to 51	40H-62	95 to 101
Standard temperature, °F	60			
Subdivision, °API	0.1			
Intermediate lines at, °API	0.5			
Main (numbered) lines at, °API	1.0			
Scale error at any point not to exceed, °API	0.2			
Total length, mm	158 to 168			
Length of nominal scale, mm	48 to 61			
Scale extension beyond nominal range limits, max	0.2 °API			
Body diameter, mm	12 to 15			
Stem diameter min, mm	2.5			

API Gravity Thermohydrometers	
For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)	
Thermometer Scale in Body	
ASTM Hydrometer No.	Nominal API Gravity Range, deg
41H-66	15 to 23
42H-66	22 to 30
43H-66	29 to 37
44H-66	36 to 44
45H-66	43 to 51
Hydrometer	
Total length, mm	374 to 387
Body diameter, mm	18 to 25
Stem diameter, min, mm	4.0
Hydrometer Scale	

Standard temperature, °F	60
Subdivisions, ° API	0.1
Intermediate lines at,° API	0.5
Main (numbered) lines at, ° API	1.0
Scale error at any point not to exceed,° API	0.1
Length of nominal scale, mm	125 to 145

Thermometer Scale	
Range, °F[B]	0 to 150 Designation L 30 to 180 Designation M 60 to 220 Designation H
Immersion	total
Subdivisions, °F	2
Intermediate lines at,° F	10
Main (numbered) lines at, °F	20
Scale error at any point not to exceed,° F	1
Scale length, mm	80 to 110

API Gravity Thermohydrometers			
For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)			
Thermometer Scale in Body		Thermometer Scale in Stem	
ASTM Hydrometer No.	Nominal API Gravity Range, deg	ASTM Hydrometer No.	Nominal API Gravity Range, deg
51H-62	–1 to + 11	71H-62	–1 to + 11
52H-62	9 to 21	72H-62	9 to 21
53H-62	19 to 31	73H-62	19 to 31
54H-62	29 to 41	74H-62	29 to 41
55H-62	39 to 51		
56H-62	49 to 61		
57H-62	59 to 71		
58H-62	69 to 81		
59H-62	79 to 91		
60H-62	89 to 101		

Hydrometer		
Total length, mm	374 to 387	374 to 387
Body diameter, mm	18 to 25	23 to 27
Stem diameter, min, mm	4.0	6.0

Hydrometer Scale	
Standard temperature, °F	60
Subdivisions, °API	0.1
Intermediate lines at, °API	0.5
Main (numbered) lines at, °API	1.0
Scale error at any point not to exceed, °API	0.1
Length of nominal scale, mm	125 to 145

Thermometer Scale		
Range, °F[C]	0 to 150 Designation L 30 to 180 Designation M 60 to 220 Designation H	30 to 220
Immersion	total	total
Subdivisions, °F	2	2
Intermediate lines at,° F	10	10
Main (numbered) lines at, °F	20	20
Scale error at any point not to exceed, °F	1	1
Scale length, mm	80 to 110	105 to 145

Relative Density (Specific Gravity) Thermohydrometer	
For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)	
Thermometer Scale in Body	
ASTM Hydrometer No.	Nominal Rel. Density (Sp. Gr.) Range
101H-03	0.500 to 0.650

Hydrometer	
Total length, mm	354 to 387
Body diameter, mm	19 to 22
Stem diameter min, mm	10.5
Working pressure min, psi	200

Hydrometer Scale	
Standard temperature, °F	60/60
Subdivisions	0.001
Intermediate lines at	0.005
Main (numbered) lines at	0.010
Scale error at any point not to exceed	0.001
Length of nominal scale, mm	125 to 145

Thermometer Scale	
Range, °F	30 to 90
Immersion	total

Subdivisions, °F	1
Intermediate lines at, °F	5
Main (numbered) lines at, °F	10
Scale error at any point not to exceed, °F	0.5
Scale length, mm	50 to 70

	Relative Density (Specific Gravity) Hydrometers			
	For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)		For General Use	
	ASTM Hydrometer No.	Nominal Rel. Density (Sp. Gr.) Range	ASTM Hydrometer No.	Nominal Rel. Density (Sp. Gr.) Range
	102H-62	0.650 to 0.700	125H-62	1.000 to 1.050
	103H-62	0.700 to 0.750	126H-62	1.050 to 1.100
	104H-62	0.750 to 0.800	127H-62	1.100 to 1.150
	105H-62	0.800 to 0.850	128H-62	1.150 to 1.200
	106H-62	0.850 to 0.900	129H-62	1.200 to 1.250
	107H-62	0.900 to 0.950	130H-62	1.250 to 1.300
	108H-62	0.950 to 1.000	131H-62	1.300 to 1.350
			132H-62	1.350 to 1.400
			133H-62	1.400 to 1.450
			134H-62	1.450 to 1.500
			135H-62	1.500 to 1.550
			136H-62	1.550 to 1.600
			137H-62	1.600 to 1.650
			138H-62	1.650 to 1.700
			139H-62	1.700 to 1.750
			140H-62	1.750 to 1.800
			141H-62	1.800 to 1.850
Standard temperature, °F		60/60		
Subdivisions		0.001		
Intermediate lines at		0.005		
Main (numbered) lines at		0.010		
Scale error at any point not to exceed		0.001		
Total length, mm		250 to 270		
Length of nominal scale, mm		70 to 85		
Scale extension beyond nominal range limits, max		0.005		
Body diameter, mm		20 to 24		
Stem diameter min, mm		4.0		

	Soil Hydrometers (55 dynes/cm or less)			
	ASTM Hydrometer No.	Nominal Rel. Density (Sp. Gr.) Range	ASTM Hydrometer No.	Nominal Range
	151H-05	0.995 to 1.038 sp gr	152H-05	–5 to + 60 g/L
Standard temperature, °F	68/68		68/68	
Divisions	0.001 sp gr		1 g/L	
Intermediate lines at	0.005 sp gr		5 g/L	
Main (numbered) lines at	0.010 sp gr		10 g/L	
Scale error at any point not to exceed	0.001 sp gr		1 g/L	
Length of nominal scale	See Fig. 2		See Fig. 2	
Total length, mm	278 to 282		278 to 282	
Body diameter	See Fig. 2		See Fig. 2	
Stem diameter	See Fig. 2		See Fig. 2	

	Pounds Per Gallon Hydrometers	
	For Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)	
	ASTM Number	Nominal Range, lb/gal
	293H-68	5.83 to 6.24
	294H-68	6.24 to 6.66
	295H-68	6.66 to 7.08
	296H-68	7.08 to 7.50
	297H-68	7.50 to 7.91
	298H-68	7.91 to 8.33
Standard temperature, °F	60°F	
Subdivisions	0.005	
Intermediate lines at	0.01	
Main (numbered) lines at	0.05	
Scale error at any point not to exceed	0.005	
Total length, mm	325 to 335	
Length of nominal scale, mm	125 to 145	
Scale extension beyond nominal range limits	0.025	
Body diameter, mm	23 to 27	
Stem diameter min, mm	5.0	

Thermohydrometers		
	ASTM Hydrometer No.	API°
	255H-03	37 to 49
	258H-03	64 to 76
Hydrometer		
Total length, mm		385 to 405
Body diameter, mm		18 to 25
Nominal stem diameter, mm		>4
Hydrometer Scale		
Standard temperature, °F		60
Subdivisions, API		0.1
Intermediate lines at, API		0.5
Main (numbered) lines at, API		1
Scale error at any point not to exceed, API		0.1
Length of nominal scale, mm		125 to 145
Thermometer Scale		
Range, °F		0 to 100°
Immersion		total
Subdivisions, °F		0.5
Short intermediate lines at, °F		1
Long intermediate lines at, °F		5
Main (numbered) lines at, °F		10
Scale error at any point not to exceed, °F		0.5
Scale length, mm		110 to 140

Thermohydrometers		
	ASTM Hydrometer No.	Density, Range, kg/m^3
	300H-82	600 to 650
	301H-82	650 to 700
	302H-82	700 to 750
	303H-82	750 to 800
	304H-82	800 to 850
	305H-82	850 to 900
	306H-82	900 to 950
	307H-82	950 to 1000
	308H-82	1000 to 1050
	309H-82	1050 to 1100
Hydrometer		
Total length, mm		374 to 387
Body diameter, mm		18 to 25
Stem diameter, min, mm		4.0
Hydrometer Scale		
Standard temperature °C		15
Subdivisions, kg/m^3		0.5
Short intermediate lines at, kg/m^3		1
Long intermediate lines at, kg/m^3		5
Main (numbered) lines at kg/m^3		10
Scale error at any point not to exceed, kg/m^3		0.5
Length of nominal scale, mm		125 to 145
Scale extension beyond nominal range limits, kg/m^3		2.5
Thermometer Scale		
Range, °C		designation –20 to + 65 L 0 to + 85 M + 20 to + 105 H
Thermometer Scale		
Immersion		total
Subdivisions, °C		1.0
Intermediate lines at, °C		5
Main (numbered) lines at, °C		10
Scale error at any point not to exceed, °C		1.0
Scale length, mm		80 to 100
Thermohydrometer (Pressure)		
	ASTM Hydrometer No.	Density Range, kg/m^3
	310H	500–650
Hydrometer		
Nominal length, mm		387
Body diameter, mm		16 to 22
Nominal stem diameter, mm		10.5
Working pressure, kPa		1400