Designation: E 100 – 95

Standard Specification for ASTM Hydrometers[1]

This standard is issued under the fixed designation E 100; 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 Department of Defense.

1. Scope

1.1 This specification covers glass hydrometers graduated in systems required by the various tests in which their use is required.

2. Referenced Documents

2.1 *ASTM Standards:*

D 287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)[2]

D 1250 Guide for Petroleum Measurement Tables[2]

E 1 Specification for ASTM Thermometers[3]

E 77 Test Method for Inspection and Verification of Thermometers[3]

E 126 Test Method for Inspection and Verification of Hydrometers[3]

E 344 Terminology Relating to Thermometry and Hydrometry[3]

3. Terminology

3.1 *Definitions*—The definitions given in Terminology E 344 apply.

3.2 *Definitions of Terms Specific to This Standard:*

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

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

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

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.

NOTE 1—Changes in this specification may be made from time to time which do not affect the basic characteristics of the hydrometers. Hydrometers manufactured prior to the adoption of the specifications will retain the same official status as those meeting current specifications.

5. Type

5.1 Hydrometers shall be of the constant-mass, variable-displacement type. Hydrometers shall be made of glass, except for the scale, ballasting material, 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.

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, striae, 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 also 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.

NOTE 2—The API hydrometers are intended to be used in conjunction with Test Method D 287, hydrometer readings being corrected using Guide D 1250, IP 200. Therefore, these hydrometers shall be made of glass having a cubical coefficient of expansion of approximately 0.0000128/1°F at 60°F.

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 a cement is used to hold the ballast securely in place, this cement shall not soften below 105°C (221°F).

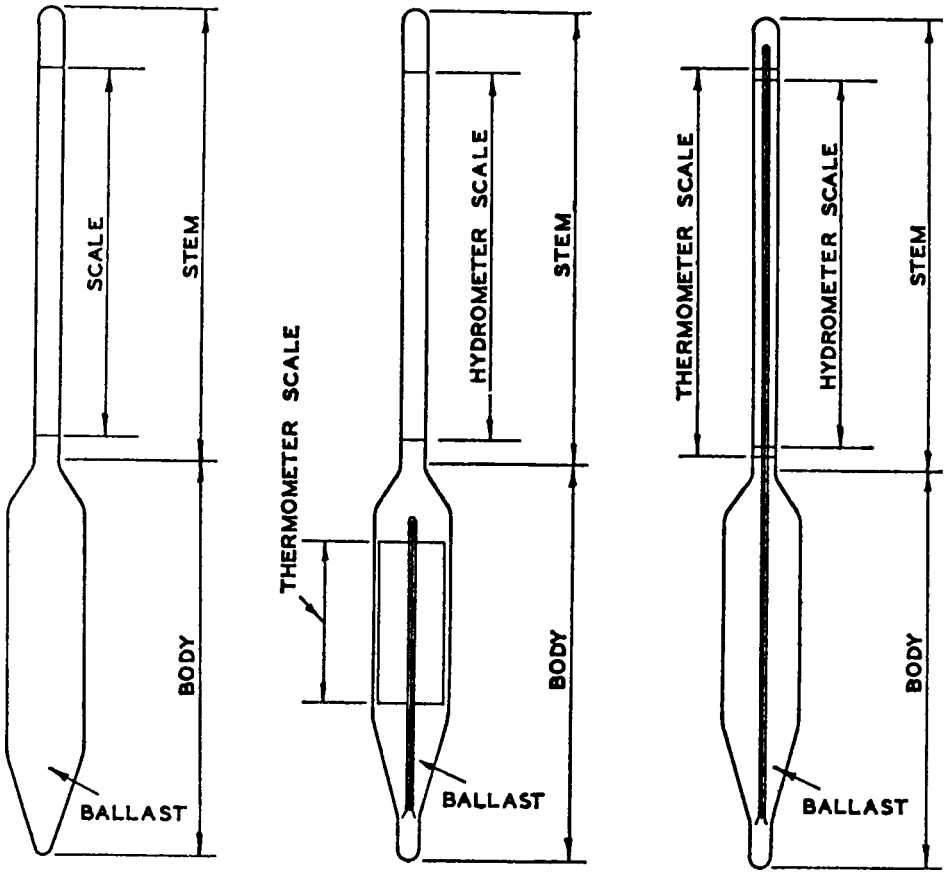
7.2 When mercury is used for weighting, it shall be placed in a small bulb below the main bulb of the hydrometer, and completely separated from the main bulb by means of a glass

[1] This specification is under the jurisdiction of ASTM Committee E-20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.05 on Liquid-in-Glass Thermometers and Hydrometers.

Current edition approved Feb. 15, 1995. Published April 1995. Originally published as E 100 – 53. Last previous edition E 100 – 94.

[2] *Annual Book of ASTM Standards,* Vol 05.01.

[3] *Annual Book of ASTM Standards,* Vol 14.03.



(a) Plain Hydrometer

(b) Thermohydrometer with Thermometer in Body

(c) Thermohydrometer with Thermometer in Stem

FIG. 1 Typical Hydrometers Designs

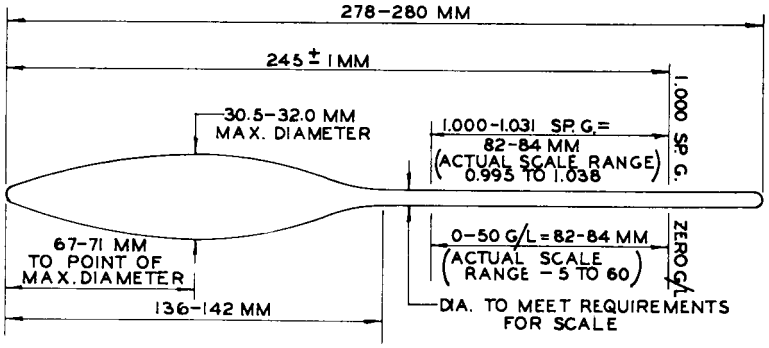


FIG. 2 Soil Hydrometers

partition or by sealing the small opening between bulbs with a suitable cement. Solid material, such as shot, also may be placed in a similar small bulb.

8. Stem

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

9. Scale

9.1 The material for the scale is optional. If paper is used, only No. 1 sulfite paper or ledger paper shall be used. The scale may be anchored by a design which prevents it from moving; otherwise it shall be fixed in place with a 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 must 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, and the subdivision lines, shall be so chosen as to facilitate readings. The shortest lines shall be at least 2 mm long.

10.3 All numbers of the API hydrometers must be complete. The numbers for 0.050 lines on specific gravity and density hydrometers must 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 For cemented scales, there shall be a permanent reference mark on the stem of the hydrometer corresponding to a designated reference mark on the scale.

11. Graduation

11.1 All hydrometers shall be graduated to read correctly where the plane of the level liquid surface intersects the stem.

11.2 Hydrometers indicating density shall be graduated to indicate, at the temperature marked on the scale, the density of liquids in kilograms per cubic metre.

11.3 Specific gravity hydrometers shall be graduated to indicate the ratio of the mass of a unit volume of the liquid at the stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature.

11.4 API hydrometers shall be graduated to give degrees of API gravity obtained as follows:

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

11.5 A list of liquids suitable for comparison tests of hydrometers will be found in Table 1 of Test Method E 126.

12. Thermohydrometers

12.1 The thermometer shall be of the mercury-in-glass type, unless otherwise specified.

12.2 The capillary stem shall be essentially parallel to the hydrometer axis.

12.3 When the thermometer scale is located in the stem of the hydrometer, the scale shall be in red to distinguish it from the hydrometer scale.

12.4 When the thermometer scale is in the stem, calibration and testing of the thermometer shall be based on immersion of the thermometer scale to the level of the mercury in the thermometer stem (total immersion).

12.5 The requirements in Section 9 for the scale of the hydrometer shall apply also to the scale of the thermometer.

12.6 The thermometer shall be calibrated in accordance with Test Method E 77.

13. Special Inscription

13.1 There shall appear on the scale or an extension thereof, or on a suitable label cemented permanently to the inside of the instrument, an inscription that indicates the purpose of the hydrometer. If necessary, this inscription should denote the liquid for which the hydrometer is intended, the temperature at which it is to be used, and the character of the indication.

13.2 The designation of standard temperature and reference temperature may be abbreviated, for example, sp gr 60/60°F, means that the hydrometer indicates at 60°F the specific gravity of the liquid, referred to water at 60°F as unity.

13.3 The inscription shall include also the hydrometer number (1H, 6H, etc.) but not the year designation (62, etc.); a unique serial number; and the name or trademark of the manufacturer or vendor.

14. Standardization

14.1 When tests are made at three scale points, the points shall include at least 60 % of the graduated interval of the scale. Neither of the extreme points shall be farther from the nearest end of the graduated scale than a distance represented by 25 % of the length of the graduated scale. No two adjacent points shall be farther apart than a distance represented by 50 % of the length of the graduated scale.

NOTE 3—When testing thermohydrometers, the thermometer in the instrument shall not be used to determine the temperature of the bath. An ASTM Gravity Thermometer as prescribed in Specification E 1, or an instrument of equal sensitivity and accuracy, must be used.

15. Case

15.1 The hydrometer shall be supplied in a suitable carton on which shall appear the ASTM number, name, and range, as given in Table 1.

16. Method for Inspection, Test, and Standardization

16.1 Hydrometers shall be inspected, tested, and standardized in accordance with Test Method E 126.

17. Keywords

17.1 ballast; body; hydrometers; specific gravity; stem; thermohydrometers

TABLE 1 Specifications for ASTM Hydrometers

API Gravity Hydrometers		Specific Gravity Hydrometers		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 Specific Gravity Range	ASTM Hydrometer No.	Nominal Specific Gravity 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
				118H-62	1.350 to 1.400
				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	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

TABLE 1 *Continued*

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

TABLE 1 *Continued*

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

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 Specific Gravity Range
101H-62	0.500 to 0.650

Hydrometer	
Total length, mm	354 to 366
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

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 Specific Gravity Range	ASTM Hydrometer No.	Nominal Specific Gravity 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

TABLE 1 *Continued*

Stem diameter min, mm	4.0			
	Soil Hydrometers			
	ASTM Hydrometer No.	Nominal Specific Gravity Range	ASTM Hydrometer No.	Nominal Range
	151H-62	0.995 to 1.038 sp gr	152H-62	–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	Calibration Liquids
	293H-68	5.83 to 6.24	isopropyl ether-ethyl alcohol
	294H-68	6.24 to 6.66	ethyl alcohol-water
	295H-68	6.66 to 7.08	ethyl alcohol-water
	296H-68	7.08 to 7.50	ethyl alcohol-water
	297H-68	7.50 to 7.91	ethyl alcohol-water
	298H-68	7.91 to 8.33	ethyl alcohol-water
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.	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

TABLE 1 *Continued*

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
Hydrometer Scale	
Standard temperature, °C	15
Subdivisions, kg/m^3	1
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	1
Length of nominal scale, mm	125 to 145
Thermometer Scale	
Range, °C	0 to 35
Immersion	total
Subdivisions, °C	0.5
Short intermediate lines at, °C	1
Long intermediate lines at, °C	5
Main (numbered) lines at, °C	10
Scale error at any point not to exceed,° C	0.5
Scale length, mm	50 to 80

Hydrometers

Hydrometer No.	Density, Range, kg/m^3
311H-82	600 to 650
312H-82	650 to 700
313H-82	700 to 750
314H-82	750 to 800
315H-82	800 to 850
316H-82	850 to 900
317H-82	900 to 950
318H-82	950 to 1000
319H-82	1000 to 1050
320H-82	1050 to 1100
Hydrometer	
Total length, mm	325 to 335
Body diameter, mm	21 to 27
Stem diameter, min, mm	4.5
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

[A] For specific gravities less than 0.950, alcoholic solutions may be tested with hydrometers 84H to 87H

[B] Indication of the thermometer range is made by the use of the listed designation used as a suffix to the ASTM hydrometer number. For example, 42HL is an instrument

with API gravity range of 22 to 30° API and thermometer range 0 to 150°F. An instrument with the same gravity range, but a thermometer range of 60 to 220°F would be designated 42HH. The number 45HM would identify an instrument with API gravity range of 43 to 51° API and a thermometer range of 30 to 180°F.

[C]Indication of the thermometer range is made by the use of the listed designation used as a suffix to the ASTM hydrometer number. For example, 54HL is an instrument with API gravity range of 29 to 41° API and thermometer range 0 to 150°F. An instrument with the same gravity range, but a thermometer range of 60 to 220°F would be designated 54HH. The number 57HM would identify an instrument with API gravity range of 59 to 71° API and a thermometer range of 30 to 180°F