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Designation: E2995 – 15a (Reapproved 2020)

Standard Specification for ASTM Thermohydrometers with Integral Low-Hazard Thermometers[1]

This standard is issued under the fixed designation E2995; 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 This specification covers glass thermohydrometers of various scale graduation systems, intended for use in a variety of ASTM Test Methods.

1.2 The thermohydrometers presented in this standard are not exact replacements for the thermohydrometers in Specification E100; the thermometers have larger maximum permissible scale errors than do their Hg-filled counterparts. The user should decide if these thermohydrometers are appropriate for use in his or her application.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *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)

D1250 Guide for the Use of the Joint API and ASTM Adjunct for Temperature and Pressure Volume Correction Factors for Generalized Crude Oils, Refined Products, and Lubricating Oils: API MPMS Chapter 11.1

D3290 Specification for Bond and Ledger Papers for Permanent Records (Withdrawn 2010)[3]

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

E344 Terminology Relating to Thermometry and Hydrometry

2.2 *ISO Standard:*[4]

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:*

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

3.2.4 *top of the thermohydrometer, n*—top of the finished instrument.

3.2.5 *total length, n*—overall length 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.

[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

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4. Specifications

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

4.2 Thermohydrometers shall conform to the inspection criteria found in Section 16 and the calibration and verification criteria found in Section 14.

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

4.4 At time of purchase, scale errors shall not exceed the maximum permissible 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 Standard Test Method E126 (for the hydrometer), or Standard Test Method E77 (for the integral thermometer), is recommended.

5. Type

5.1 Thermohydrometers shall be of the constant mass, variable displacement type. Thermohydrometers shall be made of glass, except for the scale, ballast, cement, and the thermometric liquid of the thermometer.

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 thermohydrometer shall float with its axis vertical in the liquids for which it is intended.

5.4 The thermohydrometer 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, strain patterns, cracks, or other imperfections that might interfere with the use of the thermohydrometer. The glass shall adequately resist the reaction of chemical agents to which thermohydrometers 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 thermohydrometers.

5.6 These thermohydrometers shall be fabricated from soda-lime glass tubing having a thermal cubical expansion coefficient of $(25 \pm 2) \times 10^{-6}$ per °C.

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

6. Body

6.1 The preferred shapes for thermohydrometers in this specification is shown in Fig. 1.

7. Ballast

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

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

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, ledger paper, meeting the specifications in Specification D3290, 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 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 thermohydrometer. The lengths of main division lines, subdivision lines, and intermediate lines, if used, shall be chosen so as to facilitate readings. The shortest lines shall be at least 2 mm long.

10.3 Identification of scale increments.

10.3.1 Scale graduations shall be numbered at ten scale division increments.

10.3.2 The numeric values displayed on the numbered scale graduations of API thermohydrometers shall be complete values corresponding to the indicated API value.

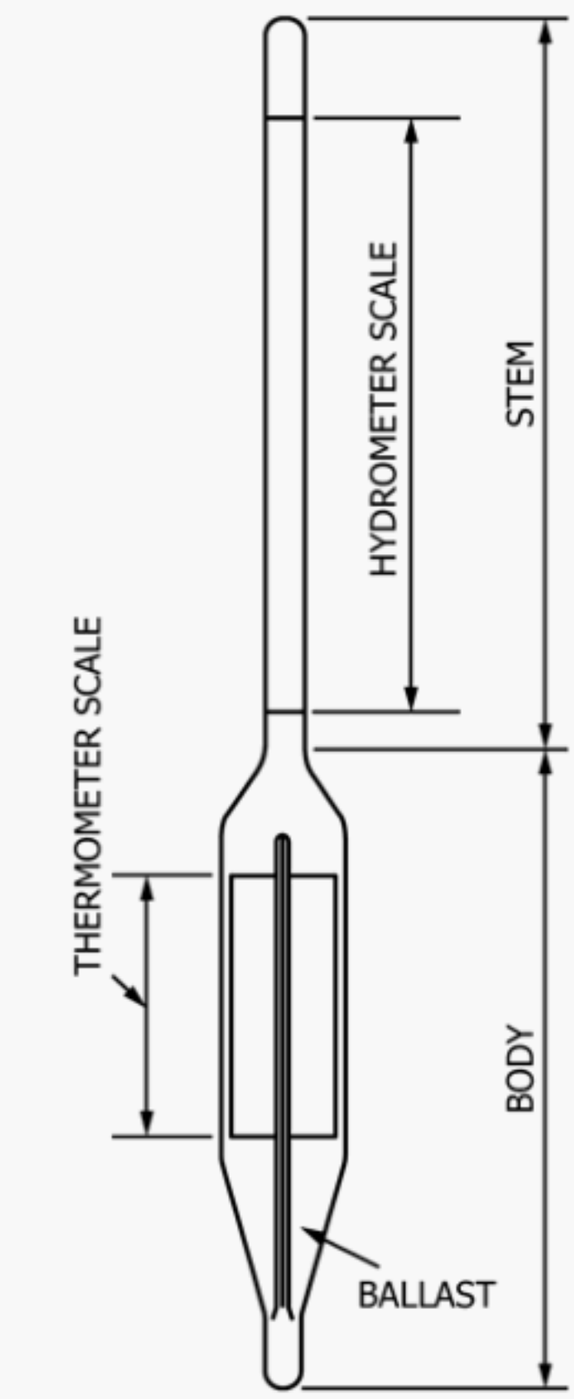
10.3.3 The numeric values displayed on the numbered scale graduations of density thermohydrometers shall be complete values at 50 kg/m^3 intervals. Numeric values appearing on intermediate numbered scale divisions may be abbreviated.

10.3.4 The numeric values displayed on the numbered scale of the thermometer shall be complete values.

10.3.5 *Scale Slippage Indicator*—There shall be a permanent reference mark on the stem of the thermohydrometer corresponding to the first numbered scale graduation. An etched mark on the stem corresponding to the first numbered graduation on the scale, an ink line on the inside of the stem corresponding to the first numbered graduation on the scale, or a length of red glass fused to the inside top of the stem and

TABLE 1 Specifications for ASTM Thermohydrometers

API Gravity Thermohydrometers for Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)	
Thermometer Scale in Body	
ASTM Thermohydrometer No.	Nominal API Gravity Range, deg
S550HL-14	-6 to +6
S551HL-14	-1 to 11
S552HL-14	9 to 21
S553HL-14	19 to 31
S554HL-14	29 to 41
S555HL-14	39 to 51
S556HL-14	49 to 61
S557HL-14	59 to 71
S558HL-14	69 to 81
S559HL-14	79 to 91
S560HL-14	89 to 101
S561HL-14	37 to 49
S562HL-14	64 to 76
Thermohydrometer Dimensions	
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	0 to 150
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	2
Scale length, mm	80 to 110
Density Thermohydrometers for Petroleum Products and Other Liquids of Similar Surface Tensions (33 dynes/cm or less)	
Thermometer Scale in Body	
ASTM Thermohydrometer No.	Nominal Range, kg/m^3 at 15 °C
S500HL-14	600 to 650
S501HL-14	650 to 700
S502HL-14	700 to 750
S503HL-14	750 to 800
S504HL-14	800 to 850
S505HL-14	850 to 900
S506HL-14	900 to 950
S507HL-14	950 to 1000
S508HL-14	1000 to 1050
S509HL-14	1050 to 1100
S510HL-14	775 to 825
Thermohydrometer Dimensions	
Total length, mm	374 to 387
Body diameter, mm	18 to 25
Stem diameter, min, mm	4.0
Hydrometer Scale	
Standardization temperature, °C	15
Subdivisions, kg/m^3 at 15 °C	0.5
Intermediate lines, kg/m^3 at 15 °C	1.0
Number lines, kg/m^3 at 15 °C	5
Main (numbered) lines, kg/m^3 at 15 °C	10
Scale error at any point not to exceed, kg/m^3 at 15 °C	0.5
Length of nominal scale, mm	125 to 145
Thermometer Scale	
Range, °C	–20 to 65
Immersion	total
Subdivisions, °C	1
Intermediate lines at, °C	5
Main (numbered) lines at, °C	10
Scale error at any point not to exceed, °C	1
Scale length, mm	80 to 110



Thermohydrometer with Thermometer in Body

FIG. 1 Typical Thermohydrometer Design

extending to the uppermost numbered graduation on the scale are examples of acceptable means for providing a scale slippage indicator.

11. Hydrometer Scale Units

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

11.2 Thermohydrometers indicating density shall be graduated to indicate the density of liquids in kg/m^3 at 15 °C.

11.3 API thermohydrometers shall be graduated to indicate degrees of API gravity.

12. Thermometer

12.1 The thermometer shall be of the liquid-in-glass type.

12.2 The thermometer fluid shall have the following characteristics:

12.2.1 Biodegradable,

12.2.2 Not appear on any suspected carcinogen list,

12.2.3 Shall equilibrate to the temperature of its environment (in a stirred liquid bath) and indicate temperature plus or minus its maximum permitted scale error within five minutes at equilibrium,

12.2.4 Shall permit repetition of temperature indication within 2/10 of one scale division,

12.2.5 Shall be dyed to provide good visual contrast against the thermometer capillary and the paper scale, and

12.2.6 The dye used shall be permanent and resistant to fading from sunlight.

12.3 The capillary stem shall be essentially parallel to the thermohydrometer axis.

12.4 The thermometer scale material shall comply with the requirements of Section 9.

12.5 The thermometer scale markings shall conform to the requirements of Section 10.

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 units of measure of the hydrometer. The thermometer shall also comply with this requirement.

13.2 The inscription shall also indicate the ASTM thermohydrometer number, which shall include the (two-digit) year of its designation or most recent revision, for example: ASTM S554HL-14.

13.3 The inscription shall also include a unique serial number and the name or trademark of the manufacturer or vendor.

14. Calibration and Verification

14.1 Calibration or verification, when required, shall be performed at three test points (approximately low, medium and high) on the hydrometer scale. For example, a thermohydrometer with a range of 9 to 21 API shall be calibrated or verified at approximately 10, 15 and 20 degrees API; a thermohydrometer with a density range of 700 to 750 kg/m^3 shall be calibrated or verified at approximately 700, 725, and 750, and so forth. Calibration or verification shall be performed in accordance with Test Method E126.

14.2 Calibration or verification of the thermometer scale, when required, shall be performed at two or more test points on the thermometer scale. Test points shall be chosen to bracket the range of use. Calibration or verification shall be performed in accordance with Test Method E77.

15. Packaging

15.1 The thermohydrometer shall be supplied in suitable packaging that will permit the viewer to visually determine the package contents, identified by ASTM number, range, and additional description as appropriate.

16. Procedure for Inspections

16.1 Manufacturers shall perform the following inspections before releasing finished instruments. For quality assurance purposes a statistically robust percentage of each lot of instruments shall be inspected. If a Certificate of Conformance, however named, is issued for each instrument, the certificate shall state the quality assurance procedure the manufacturer uses to issue the certificate.

16.2 *Visual Inspection:*

16.2.1 Inspect the hydrometer carefully to be certain there are no cracks, fissures, deep scratches, rough areas, or other obvious damage to the glass. Reject the hydrometer if any of these defects are present.

16.2.2 Inspect the hydrometer carefully for loose pieces of ballast or other foreign material within the instrument. If present, reject the instrument.

16.2.3 Inspect the paper scale within the hydrometer stem. The paper scale shall be straight and without twist.

16.2.4 Inspect for the presence of a scale slippage indicator. If a permitted scale slippage indicator is damaged, incorrectly positioned, or not present, reject the instrument.

16.3 *Dimensional Inspection:*

16.3.1 Check the linear dimensions and diameters for compliance with the Table 1 requirements by comparing the hydrometer using graduated metal rulers of the conventional type, or with metal templates with lines ruled at suitable distances from reference points corresponding to the maximum and minimum values defined in Table 1. A micrometer may be used for checking diameters.

16.3.2 Inspect the hydrometer for correctness of graduation spacing.

16.3.2.1 API hydrometers are graduated with equal spacing between scale graduations.

16.3.2.2 The interval between graduations of density hydrometers is not linear. With 50 kg ranges such as the thermohydrometers in this specification, this may be difficult to determine visually. The proper spacing may be calculated using the following equation:

$$l = L \times d_2 / d \times (d - d_1)/(d_2 - d_1) \quad (1)$$

where:

l = distance from the top line to any line, d, between the top and the bottom,
L = distance between the top and the bottom graduations of the scale,
d_1 = density value of the top, and
d_2 = density value of the bottom line.

17. Keywords

17.1 ballast; body; hydrometers; stem; thermohydrometers

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