Designation: E126 – 13a

Standard Test Method for Inspection, Calibration, and Verification of ASTM Hydrometers[1]

This standard is issued under the fixed designation E126; 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 describes the principles, apparatus, and procedures for the inspection, calibration, and verification of ASTM glass hydrometers. This test method is applicable to ASTM hydrometers and may be used for other general hydrometers of the constant-mass, variable-displacement type.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard. The metric equivalents of inch-pound units may be approximate.

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1265 Practice for Sampling Liquefied Petroleum (LP) Gases, Manual Method

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1657 Test Method for Density or Relative Density of Light Hydrocarbons by Pressure Hydrometer

E1 Specification for ASTM Liquid-in-Glass Thermometers

E77 Test Method for Inspection and Verification of Thermometers

E100 Specification for ASTM Hydrometers

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*—The definitions given in Terminology E344 apply.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *API gravity, n*—a relative index of density for petroleum products developed by the American Petroleum Institute. API gravity is defined as:

$$\text{API Gravity, deg} = [141.5/(\text{rel. density } 60/60\ °\text{F})] - 131.5 \quad (1)$$

Values of API gravity are typically expressed in degrees API, that is, 39.60 °API.

3.2.2 *comparator, n*—in this test method, a glass or other transparent cylinder to contain a liquid in which hydrometers may be compared. Examples of suitable comparators are given in Appendix X1.

3.2.3 *density, n*—mass of a unit volume of material.

3.2.3.1 *Discussion*—Units of density in hydrometers include kg/l (kilograms per liter), kg/m^3 (kilograms per cubic meter), and g/l (grams per liter); each typically expressed as mass per volume at a specified temperature, that is, kg/m^3 at 15 °C. As of this writing, only the kg/m ^{3} at 15 °C scale is offered in ASTM hydrometers (see Specification E100).

3.2.4 *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.

3.2.4.1 *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.

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

3.2.6 *thermo-hydrometer, n*—glass hydrometer having a thermometer combined with a hydrometer in one instrument.

[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.

Current edition approved Nov. 1, 2013. Published December 2013. Originally approved in 1959. Last previous edition approved in 2013 as E126 – 13. DOI: 10.1520/E0126-13a.

[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.

3.2.7 *verification, n*—confirmation, by provision of objective evidence, that the instrument fulfills specified requirements.

3.2.7.1 *Discussion*—In this test method, if the hydrometer bears an ASTM designation, the requirements for the maximum scale error and dimensions for the hydrometers given in Specification E100 apply.

3.2.8 Other descriptions of terms relating to thermometers are included in Test Method E77. Any definitions of measurement uncertainty used in this standard are from Terminology E344

4. Significance and Use

4.1 The purpose of this test method is to establish a common method by which manufacturers, calibration laboratories, and users of hydrometers may inspect, verify, or calibrate them.

4.2 The goal is to provide a standard method that is simple, easily understood, and will produce reliable results.

5. Apparatus

5.1 *Graduated Metal Scales,* of the conventional type, for checking linear dimensions. If more convenient, metal templates on which lines are ruled at suitable distances from reference points corresponding to the maximum and minimum values of the specified dimensions may be used.

5.2 *Micrometers,* of the conventional type, for checking diameters.

5.3 *Polariscope,* for viewing strain patterns in the glass developed during the manufacturing of the hydrometer.

5.4 *Comparators,* for the calibration and verification of hydrometers. Suitable types are described in Appendix X1.

5.5 *Equipment,* for checking the thermometer portion of thermohydrometers as described in Test Method E77.

5.6 *Thermometer(s),* for use in pressure hydrometer cylinder comparator, ASTM 12C (-20/102 °C, 0.2° divisions), ASTM 12F (-5/215 °F, 0.5° divisions), 136C (-20/60°C, 0.2° divisions), or ASTM 136F (-5/140°F, 0.5° divisions) found in ASTM E1 or ASTM S12C (-20/102 °C, 0.2° divisions), or ASTM S12F (-5/215 °F, 0.5° divisions) found in Specification E2251.

6. Reference Standards

6.1 *Standard Hydrometers*—Standard hydrometers shall have similar dimensions and shape to the instruments to be calibrated, (when possible), and shall have dimensions and shapes similar to the instruments to be calibrated.

NOTE 1—The relative density (specific gravity) of liquids used in calibrating hydrometers may be obtained by hydrostatic weighing instead of by the use of reference standards as described above. Details of the hydrostatic weighing apparatus can be found in the *Dictionary of Applied Physics*[3] or *Density of Solids and Liquids*.[4]

[3] *Dictionary of Applied Physics*, MacMillan and Co., London, Vol 3, p. 439.

[4] "Density of Solids and Liquids," National Institute of Standards and Technology, *Circular No. 487*.

6.2 Standards shall be calibrated by either a national metrology body (such as the National Institute of Standards and Technology) or other laboratory competent to calibrate instruments of such precision. The calibration report shall provide traceability to a national metrology body and shall contain a statement of measurement uncertainty. It is desirable that the corrections be stated to one-tenth of a scale division.

6.3 Standards shall be visually inspected every six months or prior to use, whichever is longer.

6.3.1 Visual inspection shall include, but is not limited to, looking for evidence of scratches, etching, scale slippage, deposits on the glass, and discoloration. The presence of any of these defects is an indication that the standard may require re-calibration or replacement.

6.3.2 Experience has shown that the indications of hydrometers may show drift with continued use. A procedure shall be in place to demonstrate continued validity of the calibration results for the standard hydrometer. Such a procedure may include: periodic re-calibration of the standard hydrometers; measurements of hydrometers retained by the testing laboratory for use as check standards; or checks of one standard hydrometer against another.

7. Procedure

7.1 *Inspection:*

7.1.1 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.

7.1.2 Using a polariscope, inspect the hydrometer for strain in the glass, especially at the stem/body junction. If the strain appears severe and will compromise the integrity of the hydrometer, reject the instrument. This is particularly important for thermohydrometers. See Test Method E77, 6.1.4 for more details.

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

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

7.1.5 Inspect for the presence of a scale slippage indicator. Typically, this is a thin strand of red glass, fused to the inside top of the stem, and terminating at the first major graduation of the hydrometer scale; however, other schemes are permitted, such as etching a line on the glass corresponding to a reference line printed on the scale. If a permitted scale slippage indicator is damaged, incorrectly positioned, or not present, reject the instrument. See Specification E100 for more details.

NOTE 2—Hydrometers that do not carry an ASTM designation may not be required to have a scale slippage indicator. In such cases, a cautionary note on the report would be appropriate.

7.2 *Dimensional Inspection:*

7.2.1 Check the linear dimensions and diameters for compliance with Specification E100 requirements by comparing the hydrometer with the appropriate device described in 5.1 and 5.2.

7.2.2 Inspect the hydrometers for correctness of graduation spacing. API and Baumé hydrometers are graduated with equal

spacing. The interval between graduations of density and relative density (specific gravity) hydrometers is smaller near the bottom of the scale. The proper spacing shall be obtained from the following formula:

$$l = L \times d_2/d \times (d - d_1)/(d_2 - d_1) \quad (2)$$

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_2 = density value, or relative density (specific gravity), of the bottom line, and
d_1 = density value, or relative density (specific gravity), of the top line.

7.2.3 Check the scale of hydrometers graduated to read percent of alcohol by weight or by volume by comparison with the values for master scales given in the *Standard Density and Volumetric Tables*.[5]

7.3 *Calibration:*

7.3.1 *General Considerations:*

7.3.1.1 In general, each hydrometer shall be calibrated at a minimum of three calibration points, spaced approximately equally across its range, nominally high, low and mid scale. For example, a hydrometer with a range of 9° to 21° API shall be calibrated at (approximately) 10, 15, and 20 API.

NOTE 3—Certain ASTM hydrometers, notably ASTM 10H and 60H (89/101 °API) and 101H and 310H (0.600 to 0.650 relative density and 500 to 650 kg/m^3, respectively) have ranges which cannot be fully calibrated due to fluid limitations. In these cases, the hydrometers may be calibrated at two calibration points.

7.3.1.2 In order that readings shall be uniform and reproducible, the hydrometer must be clean, dry, and at the temperature of the liquid before immersing to take a reading. It is particularly important that the stem be clean so that the liquid will rise uniformly around the stem and merge into an imperceptible film on the stem.

7.3.1.3 *Cleanliness*—The readiness with which proper cleanliness can be obtained depends somewhat on the character of the liquid. Certain liquids, such as mineral oils and strong alcoholic mixtures, adhere to the stem very readily. In such cases, wiping with a lint-free cloth moistened with acetone or alcohol and drying immediately before each reading is usually sufficient. On the other hand, with weak aqueous solutions of sugar, salts, acids, and alcohol, scrupulous cleaning of the stem is required. For such liquids, two methods for preparing instruments for calibration are in common use. In one method, hydrometers are dipped in a mixture of one part concentrated sulfuric acid and two parts fuming sulfuric acid, thoroughly rinsed with water, and dried by wiping with a clean cloth. In the other method, hydrometers are washed with soap and water, dried, and wiped with a cloth moistened with alcohol to remove any residual soap film. The stems can usually be kept clean during the calibration by wiping with a lint-free cloth moistened with alcohol (preferably absolute) and drying before each reading. (**Warning—**EXTREME CAUTION–The cleaning process using concentrated sulfuric acid and fuming sulfuric acid is extremely hazardous. This process should only be carried out in a laboratory setting with appropriate equipment and trained personnel. The hydrometer must be dry before being inserted in the acids. The reaction caused by introducing a wet hydrometer into the acids may splash acids on the operator.)

7.3.1.4 *Influence of Temperature*—For a hydrometer to indicate the density of a specified liquid correctly, it is essential that the liquid be homogenous and uniform in temperature. In comparing two hydrometers having the same standard temperature and made of the same type of glass, the temperature of the liquid need not be considered since the correction required due to variation from the standard temperature is the same for both instruments. But the temperatures of the liquid, the hydrometers, and the surrounding atmosphere shall be nearly equal during the comparison; otherwise, the temperature of the liquid will be changing, causing differences in density. The operator shall allow enough time to achieve this equilibrium. To ensure homogeneity and temperature uniformity in the liquid, thorough mixing is required immediately before making measurements.

NOTE 4—Equipment such as thermometers described in 5.6, or alternative thermometric devices of equal or better accuracy, may be used, if desired.

7.3.1.5 *Influence of Surface Tension*—When a hydrometer is floated in a liquid, a small quantity of the liquid rises about the stem to form a meniscus. This liquid adhering to the stem above the general level of the liquid in which the instrument is floating has the same effect as adding to the mass of the hydrometer, thus increasing the depth of immersion.

7.3.1.6 Because a hydrometer will indicate differently in two liquids having the same density but different surface tensions, and since surface tension is a specific property of liquids, it is necessary to specify the liquid for which a hydrometer is intended. Although hydrometers of equivalent dimensions may be compared, without error, in a liquid differing in surface tension from the specified liquid, the results of comparisons of dissimilar instruments in such a liquid shall be corrected for the effect of the surface tension.

7.3.1.7 In many liquids spontaneous changes in surface tension occur due to the formation of surface films of impurities, which may come from the apparatus, the liquid, or the air. Errors from this cause may be avoided by the use of liquids not subject to such changes. However, if the liquid used is different in surface tension from the specified liquid, a correction is required when dissimilar instruments are compared, as mentioned above. A second method of avoiding these errors is to purify the surface of the calibration liquid by causing an overflow of the liquid before making an observation.

7.3.1.8 The necessity for such special manipulation is confined to the reading of hydrometers in liquids that are subject to surface contamination, such as aqueous solutions or mixtures of acids, alkalies, salts, sugar, and weak alcoholic mixtures. Oils, alcoholic mixtures of strength above 40% by volume, and other liquids of relatively low surface tension are

[5] "Standard Density and Volumetric Tables," National Institute of Standards and Technology, *Circular, No. 19*.