



Designation: D 2111 – 02

Standard Test Methods for Specific Gravity and Density of Halogenated Organic Solvents and Their Admixtures¹

This standard is issued under the fixed designation D 2111; 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 These test methods cover the determination of the specific gravity of halogenated organic solvents and solvent admixtures. They define suitable apparatus and procedures and furnish details underlying the interpretation of test data and the selection of numerical limits for agreement among interested persons and agencies.

1.2 Three methods are covered as follows:

1.2.1 *Method A*, specific gravity by means of a hydrometer.

1.2.2 *Method B*, specific gravity and density by means of a pycnometer.

NOTE 1—In referee problems, Method B may be used.

1.2.3 *Method C*, specific gravity and density by means of an electronic densitometer.

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:*

E 1 Specification for ASTM Thermometers²

E 100 Specification for ASTM Hydrometers²

3. Terminology

3.1 *Definitions:*

3.1.1 *specific gravity*—the ratio of the mass in air of a given volume of the material at a stated temperature to the mass in air of an equal volume of distilled water at a stated temperature.

3.1.1.1 *Discussion*—When the temperature of the material and of the water are the same, the specific gravity of the material is expressed as follows:

$$\text{Specific gravity } x/y^{\circ}\text{C, example } 25/25^{\circ}\text{C} \quad (1)$$

¹ These test methods are under the jurisdiction of ASTM Committee D26 on Halogenated Organic Solvents and Fire Extinguishing Agents and are the direct responsibility of Subcommittee D26.04 on Test Methods.

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² *Annual Book of ASTM Standards*, Vol 14.03.

When the temperature of the material and of the water are not the same, the specific gravity of the material is expressed as follows:

$$\text{Specific gravity } x/y^{\circ}\text{C, example } 20/4^{\circ}\text{C} \quad (2)$$

Note that when the density of water is expressed as 4°C , the specific gravity at the stated temperature is the same as density at the stated temperature. For example, SG 20/4 $^{\circ}\text{C}$ = density at 20 $^{\circ}\text{C}$.

When using an electronic densitometer to determine specific gravity, the temperature of the material to be tested and the water reference will be the same. Examples 25/25 $^{\circ}\text{C}$, 20/20 $^{\circ}\text{C}$.

3.1.2 *density*—the mass of a given material per unit volume.

3.1.2.1 *Discussion*—Density for chlorinated solvents is normally stated in grams per cubic centimetre. Pounds per gallon is also commonly used.

4. Significance and Use

4.1 The density or specific gravity of a pure chlorinated solvent at a given temperature is constant. Density or specific gravity can be used in identification of materials, the assay of binary mixtures, and as an indication of purity of a given solvent.

5. Test Temperatures

5.1 ASTM specifications normally state the temperatures for specific gravity of halogenated organic solvents at 25/25 $^{\circ}\text{C}$. 20/20 $^{\circ}\text{C}$ and 60/60 $^{\circ}\text{F}$ are other commonly used temperatures.

METHOD A—SPECIFIC GRAVITY BY MEANS OF A HYDROMETER

6. Apparatus

6.1 *Hydrometer*—The hydrometers to be used shall be those specified in Specification E 100, as follows:

Nominal Specific Gravity Range	ASTM Hydrometer No.
0.900 to 0.950	107H
0.950 to 1.000	108H
1.000 to 1.050	125H
1.050 to 1.100	126H
1.100 to 1.150	127H
1.150 to 1.200	128H
1.200 to 1.250	129H
1.250 to 1.300	130H
1.300 to 1.350	131H
1.350 to 1.400	132H
1.400 to 1.450	133H
1.450 to 1.500	134H

1.500 to 1.550	135H
1.550 to 1.600	136H
1.600 to 1.650	137H

6.2 *Hydrometer Cylinder*—The vessel in which the sample for the gravity test is confined shall be made of clear glass and shall be cylindrical in shape. For convenience in pouring, it may have a lip on the rim. The inside diameter shall be at least 25.0 mm (1.0 in.) greater than the outside diameter of the hydrometer used in it. The height of the cylinder shall be such that the length of the column of sample it contains is greater by at least 25.0 mm than the portion of the hydrometer that is immersed beneath the surface of the sample after a state of equilibrium has been reached.

6.3 *Thermometer*—An ASTM Gravity Thermometer having a range from -20 to $+102^{\circ}\text{C}$ and conforming to the requirements for Thermometer 12C as prescribed in Specification E 1.

6.4 *Water Bath*, capable of maintaining the test temperature $\pm 0.5^{\circ}\text{C}$ during the test.

7. Procedure

7.1 Cool the sample in the original container to about 1°C below the test temperature. Rinse each piece of equipment with a portion of the sample. Pour the sample into the clean hydrometer cylinder without splashing, so as to avoid formation of air bubbles. Remove any air bubbles adhering to the surface by touching them with a piece of clean filter paper. Select a location that is free of air currents. Place the cylinder vertically in the water bath and let the temperature of the sample reach the test temperature as follows: Stir the contents of the cylinder, being careful to avoid formation of air bubbles. When the temperature of the sample is 0.5°C below the test temperature, slowly and carefully lower the hydrometer into the sample to a level two smallest scale divisions below that at which it will float, and then release the hydrometer. After it has come to rest and floats freely away from the walls of the cylinder, read the gravity as the point at which the surface of the sample apparently cuts the hydrometer scale.

7.2 When the sample is at the test temperature, make this observation by placing the eye slightly below the level of the liquid and slowly raise the eye until the surface of the sample first seen as a distorted ellipse seems to become a straight line cutting the hydrometer scale. Determine the temperature of the sample just before and also, for referee tests, just after reading the hydrometer.

METHOD B—SPECIFIC GRAVITY OR DENSITY BY MEANS OF A PYCNOMETER

8. Apparatus

8.1 *Pycnometer*, 25-mL capacity with a ground-glass stopper having a capillary opening, a chamber to provide for expansion up to room temperature, and a cap to prevent evaporation.

8.2 *Water Bath*, capable of maintaining the temperature $\pm 0.5^{\circ}\text{C}$ during the test.

8.3 *Thermometer*—An ASTM Low Softening Point Thermometer having a range from -2 to $+80^{\circ}\text{C}$ and conforming to the requirements for Thermometer 15C as prescribed in Specification E 1.

8.4 *Analytical Balance*, having a sensitivity of ± 0.1 mg.

9. Procedure—Specific Gravity

9.1 Clean the pycnometer by filling it with a saturated solution of chromic acid in concentrated sulfuric acid allowing it to stand for a few hours, emptying, and rinsing well with distilled or deionized water.

9.2 Fill the pycnometer with freshly boiled distilled or deionized water that has been cooled to 2 or 3°C below the test temperature. Place it in the water bath maintained at the test temperature until the pycnometer and its contents are at a constant volume.

9.3 After immersion in the bath for at least 30 min, adjust the level of liquid to the proper point on the pycnometer, put the stopper in place, remove from the bath, wipe dry, and weigh. Care should be taken to avoid touching the pycnometer with bare hands due to weight changes that will occur from picking up moisture and oils. Record the weight as W_1 .

9.4 Empty the pycnometer, rinse successively with alcohol or acetone, remove the vapor of the solvent by purging with clean, dry air or nitrogen, immerse in the bath, and bring to the test temperature as was done before. After immersion at the test temperature for at least 30 min, put the stopper in place, remove from the bath, wipe dry, and weigh. Record the weight as W_2 .

9.5 Subtract the weight of the empty pycnometer from the weight when filled with water in order to get the weight of the contained water at the test temperature in air. The difference $W = W_1 - W_2$.

9.6 Cool the sample to 2 or 3°C below the test temperature, fill the pycnometer with it, immerse in the bath, and bring to the test temperature as was done before. After immersion at the test temperature for at least 30 min, adjust the liquid level, put the stopper in place, remove from the bath, wipe dry, and weigh. Record the temperature as S_j .

9.7 Subtract the weight of the empty pycnometer from the weight when filled with the sample in order to obtain the weight of the contained sample. The difference $S = S_j - W_2$.

10. Calculation

10.1 Calculate the specific gravity (in air) as follows:

$$\text{Specific gravity } T/T = S/W \quad (3)$$

where:

T = test temperature

10.2 Material specifications often specify different temperatures at which specific gravity shall be measured. In order to convert to any selected temperature, the coefficient of cubical expansion for the material being tested must be used. In addition, the absolute density of water at the desired temperature is taken. The absolute densities of water at different temperatures are tabulated in various handbooks. In converting to any desired temperature basis, the following equation is used:

$$\text{Specific gravity } T_3/T_4^{\circ}\text{C} = \frac{\text{specific gravity } T_1/T_2}{[1 + k(T_3 - T_1)] \frac{d_{H_2O} \text{ at } T_4}{d_{H_2O} \text{ at } T_2}} \quad (4)$$