Designation: D1555 – 21

Standard Test Method for Calculation of Volume and Weight of Industrial Aromatic Hydrocarbons and Cyclohexane[1]

This standard is issued under the fixed designation D1555; 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 standard is for use in calculating the weight and volume of benzene, toluene, mixed xylenes, styrene, orthoxylene, meta-xylene, para-xylene, cumene, ethylbenzene, 300 to 350°F and 350 to 400°F aromatic hydrocarbons, and cyclohexane. A method is given for calculating the volume at a desired temperature t_b°F from an observed volume at t_o°F. Table 1 lists the density *in Vacuo* at 60°F for chemicals used to develop the relationship. Densities (or weights) "*in vacuo*" represent the true density (or weight) if measured in a vacuum without the buoyancy effect of air acting on the liquid. It is representative of the actual amount of product present. Densities (or weights) "*in air*" represent what would actually be measured on a scale. The difference is on the order of 0.13 %. Modern densitometers measure density *in vacuo* and the ASTM recommends the use of *in vacuo* densities (or weights).

1.2 The values stated in inch-pound units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 A complete SI unit companion standard has been developed in Test Method D1555M.

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]

D1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer

D1555M Test Method for Calculation of Volume and Weight of Industrial Aromatic Hydrocarbons and Cyclohexane [Metric]

D3505 Test Method for Density or Relative Density of Pure Liquid Chemicals

D4052 Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

2.2 *Other Documents:*

American Petroleum Society Research Project 44[3]

Patterson, J. B., and Morris, E. C. *Metrologia*, 31, 1994, pp. 277-288

NSRDS-NIST 75-121 TRC Thermodynamic Tables—Hydrocarbons, Supplement No. 121, April 30, 2001[4]

3. Significance and Use

3.1 This test method is suitable for use in calculating weights and volumes of the products outlined in Section 1. The information presented in this method can be used for determining quantities of the above-stated aromatic hydrocarbons in tanks, shipping containers, etc.

4. Basic Data

4.1 Densities of materials should be determined by measurement (see Section 7). Densities of pure materials at 60°F may be estimated from densities furnished by NSRDS-NIST 75-121 (National Standard Reference Data Series—National Institute of Standards and Technology).

[1] This test method is under the jurisdiction of ASTM Committee D16 on Aromatic, Industrial, Specialty and Related Chemicals and is the direct responsibility of Subcommittee D16.01 on Benzene, Toluene, Xylenes, Cyclohexane and Their Derivatives.

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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] "Selected Values of Properties of Hydrocarbons and Related Compounds," prepared by American Petroleum Institute Research Project 44 at the Chemical Thermodynamics Center, Department of Chemistry, Texas A&M, College Station, TX.

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

TABLE 1 Physical Properties

Product	Freezing Point °F	Boiling Point °F	Density *in Vacuo* at 60°F g/cc[A,B]	Density *in Vacuo* at 60°F lb/gal[C]	Density *in Air* at 60°F lb/gal[D]
Benzene	42.0	176.2	0.88373	7.3751	7.3662
Cumene	-140.9	306.3	0.86538	7.2219	7.2130
Cyclohexane	43.8	177.3	0.78265	6.5315	6.5225
Ethylbenzene	-139.0	277.1	0.87077	7.2669	7.2580
Styrene	-23.1	293.4	0.90979	7.5926	7.5837
Toluene	-139.0	231.1	0.87096	7.2685	7.2596
m-Xylene	-54.2	282.4	0.86784	7.2425	7.2336
o-Xylene	-13.3	291.9	0.88340	7.3723	7.3634
p-Xylene	55.9	281.0	0.86456	7.2151	7.2062

[A] Based on regression of 2001 TRC Thermodynamic Tables, Hydrocarbons, NSRDS-NIST 75-121 (April 30, 2001). The data is presented in Appendix X1.
[B] Specific Gravity has been deleted from this table as unnecessary to this standard. If needed, divide 60°F density in g/cc by 0.999016 g/cc. See Appendix X2.
[C] Produced by multiplying the density *in vacuo* at 60°F in g/cc by 8.345404452 and rounding to 4 decimal places.
[D] Produced using Density - g/cc *in air* · 1.000149926 – 0.001199407795) · 8.345404452, rounding to 4 decimal places. See Appendix X3.

4.2 The VCF (Volume Correction Factor) equations provided below were derived from the Volume Correction Tables presented in the previous edition of this standard, Method D1555-95. Although reported as based on the American Petroleum Institute Research Project 44, the actual documentation that could be found is incomplete. As regression of the NIST data (Appendix X1) provided VCFs that differ from the historical VCFs by only 0 to ± 0.12 % (depending on the compound), a decision was made to use the previous method's VCF tables.

4.3 The VCF tables were regressed with a commercially available data regression program (TableCurve 2D V4). However, any modern regression program should produce the same results.

4.4 The former VCF tables were based on data for compounds used in American Petroleum Institute Research Project 44 for which the purity is not clearly defined, but were reported to be usable for materials in the ranges indicated in Table 2. The data supporting this conclusion appears to be unavailable at the present time; however there is no reason to change this recommendation. If, depending on the composition of the impurities, there is reason to suspect that the VCF implementation procedures presented below do not apply to a particular impure product, a separate implementation procedure should be independently determined. This may be done by measuring the density of a representative sample at different temperatures throughout the expected working temperature range, regressing the data to obtain a temperature/density equation that best reproduces the observed data, and then dividing the constants of the temperature/density equation by the calculated density at 60°F.

TABLE 2 Application Range of Implementation Procedure

Impure Products	Range
Benzene	95 to 100 %
Cumene	95 to 100 %
Cyclohexane	90 to 100 %
Ethylbenzene	95 to 100 %
Styrene	95 to 100 %
Toluene	95 to 100 %
Mixed Xylenes	All proportions
m-Xylene	95 to 100 %
o-Xylene	95 to 100 %
p-Xylene	94 to 100 %
300-350°F Aromatic Hydrocarbons	All proportions
350-400°F Aromatic Hydrocarbons	All proportions

5. Volume Correction Factor Implementation Procedure

5.1 The following general equation is used to generate the Volume Correction Factors:

$$VCF = \frac{a + bt_o + ct_o^2 + dt_o^3 + et_o^4}{a + bt_b + ct_b^2 + dt_b^3 + et_b^4} \quad (1)$$

where:

t_o = observed temperature, and
t_b = base temperature where value is needed.

and constants a through e are specific to each compound (presented in Table 3).

5.1.1 Temperature may be entered in tenths of a degree Fahrenheit.

5.1.2 The calculated result is rounded to the appropriate significant figures if it is to be reported and not rounded if to be used in another calculation. No intermediate rounding or truncation should be done.

5.1.3 The equations are valid for liquid product up to 140°F (150°F for *p*-xylene).

5.1.4 This implementation procedure replaces the printed table in a previous edition of this standard (Method D1555 – 95) for determining VCFs. **The implementation procedure is the Standard, not the printed table.** However, the printed table is provided in 1°F increments for the user's convenience (Table 4).

6. Use of the Implementation Procedure

6.1 *Convert Volume to 60°F*—Enter the appropriate equation with the temperature to the nearest 0.1 degree Fahrenheit at which the bulk volume was measured (temperature *t*). Multiply the bulk volume measurement at temperature *t* by the VCF.

6.1.1 *Example 1*—What is the volume at 60°F of a tank car of *p*-xylene whose volume was measured to be 9280 gal at a mean temperature of 88.7°F?