



Designation: D1555M – 22

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

This standard is issued under the fixed designation D1555M; 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 standard is for use in calculating the weight and volume of benzene, toluene, mixed xylenes, styrene, ortho-xylene, meta-xylene, para-xylene, cumene, ethylbenzene, 148.9 to 176.7 °C and 176.7 to 204.4 °C aromatic hydrocarbons, and cyclohexane. A method is given for calculating the volume at a given temperature from an observed volume at an observed temperature, t °C. Table 1 lists the density *in Vacuo* at 15 °F and 20 °C 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 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 SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.2.1 A complete inch-pound unit companion standard has been developed in Test Method D1555.

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.*

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. Referenced Documents

2.1 ASTM Standards:²

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

D1555 Test Method for Calculation of Volume and Weight of Industrial Aromatic Hydrocarbons and Cyclohexane

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 44³

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

TRC Thermodynamic Tables—Hydrocarbons, NSRDS-NIST 75-121, Supplement No. 121, April 30, 2001⁴

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).

4.2 The VCF (Volume Correction Factor) equations provided below are derived from the Volume Correction implementation procedures presented in Method D1555.

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>.

*A Summary of Changes section appears at the end of this standard



TABLE 1 Physical Properties

Product	Freezing Point °C	Boiling Point °C	Density <i>in Vacuo</i> at 15 °C g/cc ^{A,B,C}	Density <i>in Air</i> at 15 °C g/cc ^D	Density <i>in Vacuo</i> at 20 °C g/cc ^{C,E,F}	Density <i>in Air</i> at 20 °C g/cc ^D
Benzene	5.6	80.1	0.88431	0.88324	0.87908	0.87801
Cumene	-96.1	152.4	0.86586	0.86479	0.86160	0.86053
Cyclohexane	6.6	80.7	0.78317	0.78209	0.77849	0.77741
Ethylbenzene	-95.0	136.2	0.87126	0.87019	0.86685	0.86578
Styrene	-30.6	145.2	0.91028	0.90922	0.90586	0.90480
Toluene	-95.0	110.6	0.87147	0.87040	0.86686	0.86579
<i>m</i> -Xylene	-47.9	139.1	0.86831	0.86724	0.86408	0.86301
<i>o</i> -Xylene	-25.2	144.4	0.88387	0.88280	0.87968	0.87861
<i>p</i> -Xylene	13.3	138.3	0.86503	0.86396	0.86076	0.85969

^A Obtained from Method D1555 – 04a by multiplying the chemical's 60 °F density by the volume correction factor for 59 °F.

^B Specific Gravity at 15 °C is not presented in this table as it is unnecessary to this standard. If needed, divide 15 °C density in g/cc by 0.999102 g/cc. See Appendix X1.

^C g/cc can be converted to kg/1000L or kg/m³ by multiplying by 1000.

^D Produced using the equation: Density g/mL_{in air} = (1.000149926 × Density g/mL_{in vacuo} – 0.001199407795) and rounding to 5 decimal places. See Appendix X2.

^E Obtained from Method D1555 – 04a by multiplying the chemical's 60 °F density by the volume correction factor for 68 °F.

^F Specific Gravity at 20 °C is not presented in this table as it is unnecessary to this standard. If needed, divide 20 °C density in g/cc by 0.998206 g/cc. See Appendix X1.

4.3 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 a given temperature where the density is desired.

5. Volume Correction Factor Implementation Procedure

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

$$VCF = \frac{[a + b \times t_{o,f} + c \times t_{o,f}^2 + d \times t_{o,f}^3 + e \times t_{o,f}^4]}{[a + b \times t_{b,f} + c \times t_{b,f}^2 + d \times t_{b,f}^3 + e \times t_{b,f}^4]} \quad (1)$$

$$t_{b,f} = 1.8 \times t_{b,c} + 32$$

$$t_{o,f} = 1.8 \times t_{o,c} + 32$$

where:

VCF = Volume correction factor to base temperature from observed temperature; constants a through e are specific to each compound (obtained from Method D1555 and presented in Table 3),

$t_{b,f}$ = Desired volume correction factor base temperature in °F,

$t_{b,c}$ = Desired volume correction factor base temperature in °C,

$t_{o,f}$ = Observed density temperature in °F, and

$t_{o,c}$ = Observed density temperature in °C.

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

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 60 °C (65.5 °C for *p*-xylene).

5.1.4 This implementation procedure replaces the printed tables of previous editions of this Method for determining VCFs. **The implementation procedure is the Standard, not the printed tables.** However, the printed tables are provided in 0.5 °C increments for the user's convenience (Tables 4 and 5).

6. Use of the Implementation Procedure

6.1 *Convert Volume to Base Temperature*—Enter the appropriate equation with the temperature to the nearest 0.1 degree Celsius 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 15 °C and at 20 °C of a tank car of *p*-xylene whose volume was measured to be 35 129 L at a mean temperature of 31.7 °C?

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
<i>m</i> -Xylene	95 to 100 %
<i>o</i> -Xylene	95 to 100 %
<i>p</i> -Xylene	94 to 100 %
148.9-176.7 °C Aromatic Hydrocarbons	All proportions
176.7-204.4 °C Aromatic Hydrocarbons	All proportions