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Standard Test Method for Trace Impurities in Monocyclic Aromatic Hydrocarbons by Gas Chromatography and External Calibration¹

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1. Scope*

1.1 This test method covers the determination of the total nonaromatic hydrocarbons and trace monocyclic aromatic hydrocarbons in toluene, mixed xylenes, and *p*-xylenes by gas chromatography. The purity of toluene, mixed xylenes, or *p*-xylenes can also be calculated. Calibration of the gas chromatographic system is done by the external standard calibration technique. A similar test method, using the internal standard calibration technique, is Test Method D 2360.

1.2 Total aliphatic hydrocarbons containing 1 through 10 carbon atoms (methane through decanes) can be detected by this test method at concentrations ranging from 0.001 to 2.500 weight %.

1.2.1 A small amount of benzene in mixed xylenes or *p*-xylenes may not be distinguished from the nonaromatics and the concentrations are determined as a composite (see 6.1).

1.3 Monocyclic aromatic hydrocarbon impurities containing 6 through 10 carbon atoms (benzene through C_{10} aromatics) can be detected by this test method at individual concentrations ranging from 0.001 to 1.000 weight %.

~~1.4 The following applies to all specified limits in this test method: for purposes of determining conformance with this test method, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand digit used in expressing the specification limit, in accordance with the rounding-off method of Practice E29~~

1.4 In determining the conformance of the test results to applicable specifications, results shall be rounded off in accordance with the rounding-off method of Practice E 29.

~~1.5~~

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 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. For specific hazard statement, see Section 9.

2. Referenced Documents

2.1 *ASTM Standards*:²

D 841 [Specification for Nitration Grade Toluene](#)

D 2306 [Test Method for \$C_8\$ Aromatic Hydrocarbon Analysis by Gas Chromatography](#)

D 2360 [Test Method for Trace Impurities in Monocyclic Aromatic Hydrocarbons by Gas Chromatography](#)

D 3437 [Practice for Sampling and Handling Liquid Cyclic Products](#)

D 4052 [Test Method for Density and Relative Density of Liquids by Digital Density Meter](#)

D 4307 [Practice for Preparation of Liquid Blends for Use as Analytical Standards](#)

~~D 4534 [Test Method for Benzene Content of Cyclic Products by Gas Chromatography](#)~~²

D 4790 [Terminology of Aromatic Hydrocarbons and Related Chemicals](#)

D 5136 [Specification for High Purity *p*-Xylene](#)²

[Specification for High Purity *p*-Xylene](#)

D 5211 [Specification for Xylenes for *p*-Xylene Feedstock](#)² [Specification for Xylenes for *p*-Xylene Feedstock](#)

D 6526 [Test Method for Analysis of Toluene by Capillary Column Gas Chromatography](#)

D 6809 [Guide for Quality Control and Quality Assurance Procedures for Aromatic Hydrocarbons and Related Materials](#)

E 29 [Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

¹ This test method is under the jurisdiction of ASTM Committee D16 on Aromatic Hydrocarbons and Related Chemicals and is the direct responsibility of Subcommittee D16.04 on Instrumental Analysis.

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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.

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

E 260 [Practice for Packed Column Gas Chromatography](#)

E 355 [Practice for Gas Chromatography Terms and Relationships](#)

E 691 [Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

E 1510 [Practice for Installing Fused Silica Open Tubular Capillary Columns in Gas Chromatographs](#)

2.2 *Other Document:*

~~OSHA Regulations, 29CFR, paragraphs 1910.1000 and 1910.1200~~ OSHA Regulations, 29CFR paragraphs 1910.1000 and 1910.1200³

3. Terminology

3.1 See Terminology D 4790 for definitions of terms used in this test method.

3.2 Mixed xylenes are a mixture of C_8 aromatics including *m*-xylene, *o*-xylene, and *p*-xylene. Industry convention includes ethylbenzene as a ‘mixed xylene’ though ethylbenzene is not technically a xylene. Styrene is excluded.

4. Summary of Test Method

4.1 A repeatable volume of the specimen to be analyzed is precisely injected into a gas chromatograph equipped with a flame ionization detector (FID). The peak area of each impurity is measured. Concentration of each impurity is determined from the linear calibration curve of peak area versus concentration. Purity by gas chromatography (GC) is calculated by subtracting the sum of the impurities found from 100.00. Results are reported in weight percent.

5. Significance and Use

5.1 Determining the type and amount of hydrocarbon impurities remaining from the manufacture of toluene, mixed xylenes, and *p*-xylenes used as chemical intermediates and solvents is often required. This test method is suitable for setting specifications and for use as an internal quality control tool where these products are produced or are used. Typical impurities are: alkanes containing 1 to 10 carbon atoms, benzene, toluene, ethylbenzene (EB), xylenes, and aromatic hydrocarbons containing nine carbon atoms.

5.1.1 Refer to Test Method D 2306 for determining the C_8 aromatic hydrocarbon distribution in mixed xylenes.

5.2 Purity is commonly reported by subtracting the determined expected impurities from 100.00. However, a gas chromatographic analysis cannot determine absolute purity if unknown or undetected components are contained within the material being examined.

5.3 This test method is similar to Test Method D 2360, however, interlaboratory testing has indicated a bias may exist between the two methods. Therefore the user is cautioned that the two methods may not give comparable results.

6. Interferences

6.1 In some cases for mixed xylenes and *p*-xylene, it may be difficult to resolve benzene from the nonaromatic hydrocarbons. Therefore the concentrations are determined as a composite. In the event that the benzene concentration must be determined, an alternate method such as Test Method ~~D 4534~~ D 6526 must be selected to ensure an accurate assessment of the benzene concentration.

² Annual Book of ASTM Standards, Vol 05.02.

³ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

TABLE 1 Typical Method Parameters

Inlet	Split
Temperature, °C	270
Column:	
Tubing	fused silica
Length, m	60
Internal diameter, mm	0.32
Stationary phase	crosslinked polyethylene glycol
Film thickness, µm	0.25
Column temperature program	
Initial temperature, °C	60
Initial time, min	10
Programming rate, °C/min	5
Final, °C	150
Time 2, min	10
Carrier gas	Helium or Hydrogen
Linear velocity, cm/s at 145°C	20 Helium or 45 Hydrogen
Split ratio	100:1
Sample size, µL	1.0
Detector:	flame ionization
Temperature, °C	300
Analysis time, min	30

6.2 Complete separation of ethylbenzene and *m*-xylene from *p*-xylene is difficult and can be considered adequate if the distance from baseline to valley between peaks is not greater than 50 % of the peak height of the impurity.

7. Apparatus

7.1 *Gas Chromatograph*—Any instrument having a flame ionization detector that can be operated at the conditions given in Table 1. The system shall have sufficient sensitivity to obtain a minimum peak height response for 0.001 weight % impurity of twice the height of the background noise.

7.2 *Columns*—The choice of column is based on resolution requirements. Any column may be used that is capable of resolving all significant impurities from the major component. The column and conditions described in Table 1 have been used successfully and shall be used as a referee in cases of dispute.

7.3 *Recorder*—Electronic integration is recommended.

7.4 *Injector*—The specimen must be precisely and repeatably injected into the gas chromatograph. An automatic sample injection device is highly recommended although manual injection can be employed if the criteria in 12.7 can be satisfied.

7.5 *Volumetric Flask*, 100-mL capacity.

7.6 *Syringe*, 100 μ L.

8. Reagents

8.1 *Purity of Reagent*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society,⁴ where such specifications are available.

8.2 *Carrier Gas*—~~Chromatographic grade helium or hydrogen is recommended.~~—Chromatographic grade helium or hydrogen, 99.999 % is recommended. Purify carrier, makeup and detector gases to remove oxygen, water, and hydrocarbons.

8.3 *Air*, Chromatographic grade, containing less than 0.1 ppm THC.

8.4 *High Purity p-Xylene*, 99.999 weight % or greater purity.

8.3.1 *Most*

8.4.1 *Most p-xylene* is available commercially at a purity less than 99.9 % and can be purified by recrystallization. To prepare 1.9 L of high purity *p*-xylene, begin with approximately 3.8 L of material and cool in a flammable storage freezer at $-10 \pm 5^\circ\text{C}$ until approximately $\frac{1}{2}$ to $\frac{3}{4}$ of the *p*-xylene has frozen. This should require about 5 h. Remove the sample and decant the liquid portion. The solid portion is the purified *p*-xylene. Allow the *p*-xylene to thaw and repeat the crystallization procedure on the remaining sample until the *p*-xylene is free of contamination as indicated by gas chromatography.

8.4.2 *Pure* 8.5 *Pure* compounds for calibration, shall include *n*-nonane, benzene, toluene, ethylbenzene, *o*-xylene, *m*-xylene, and cumene. If applicable, the calibration may include paradiethylbenzene (PDEB). The purity of all reagents should be >99 weight %. If the purity is less than 99 %, the concentration and identification of impurities must be known so that the composition of the standard can be adjusted for the presence of the impurities.

9. Hazards

9.1 Consult current OSHA regulations, supplier's Material Safety Data Sheets, and local regulations for all materials used in this test method.

10. Sampling

10.1 Sample the material in accordance with Practice D 3437.

11. Preparation of Apparatus

11.1 Follow manufacturer's instructions for mounting and conditioning the column into the chromatograph and adjusting the instrument to the conditions described in Table 1, allowing sufficient time for the equipment to reach equilibrium. See Practices E260, E355, and E1510 for additional information on gas chromatography practices and terminology.

12. Calibration

12.1 Prepare a synthetic mixture of high purity *p*-xylene containing impurities at concentrations representative of those expected in the samples to be analyzed. The volume of each hydrocarbon impurity must be measured to the nearest 1 μ L and all liquid reference compounds must be brought to the same temperature before mixing. Refer to Table 2 for an example of a calibration blend. *n*-Nonane will represent the nonaromatic fraction, *o*-xylene the *o*-xylene fraction, *m*-xylene the *m*-xylene fraction. Cumene will represent the aromatic hydrocarbons containing nine carbon atoms or greater, with exception of PDEB. If PDEB is included in the calibration, PDEB will represent PDEB.

⁴Annual Book of ASTM Standards, Vol 14.02.

⁴ *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

TABLE 2 Preparation of Calibration Blend

Compound	Density ^A	Recommended Vol, μL	Resulting Concentration (including PDEB)		Resulting Concentration (excluding PDEB)	
			Volume %	Weight %	Volume %	Weight %
<i>p</i> -Xylene	0.857	99.60-99.62 ml	99.60	99.60	99.62	99.62
Benzene	0.874	20	0.020	0.020	0.020	0.020
Toluene	0.862	20	0.020	0.020	0.020	0.020
Ethylbenzene	0.863	100	0.100	0.100	0.100	0.100
<i>o</i> -Xylene	0.876	100	0.100	0.102	0.100	0.102
Cumene	0.857	20	0.020	0.020	0.020	0.020
<i>n</i> -Nonane	0.714	20	0.020	0.017	0.020	0.017
<i>m</i> -Xylene	0.864	100	0.100	0.101	0.100	0.101
PDEB	0.862	20	0.020	0.020	n/a	n/a

^A Density at 25°C. Values obtained from "Physical Constants of Hydrocarbons C_1 to C_{10} "; ASTM Publication DS 4A, 1971.

12.1.1 Prior to preparing the calibration standard, all reference compounds and any samples to be analyzed must be brought to the same temperature, preferably 25°C.

12.2 Using the exact volumes and densities in Table 2, calculate the weight % concentration for each impurity in the calibration blend as follows:

$$C_i = 100 D_i V_i / (V_t D_p) \quad (1)$$

where:

D_i = density of impurity *i* from Table 2,

V_i = volume of impurity *i*, mL,

D_p = density of *p*-xylene from Table 2,

V_t = total volume of standard blend, mL, and

C_i = concentration of impurity *i*, weight %.

12.2.1 Alternatively, calibration standards may be used that have been gravimetrically prepared in accordance with Practice D 4307.

12.3 Inject the resulting solution from 12.1 into the chromatograph, collect and process the data. A typical chromatogram is illustrated in Fig. 1.

12.4 Determine the response factor for each impurity in the calibration mixture as follows:

$$RF_i = C_i / A_i \quad (2)$$

where:

RF_i = response factor for impurity *i*,

A_i = peak area of impurity *i*, and

C_i = concentration of impurity *i*, as calculated in 12.2, weight %.

12.5 Analyze the calibration solution(s) a minimum of three times and calculate an average RF .

12.6 Determine the sample standard deviation for RF of each impurity using a scientific calculator or spreadsheet program. Determine the coefficient of variation for each RF as follows:

$$CV_i = 100 SD_i / Avg_i \quad (3)$$

where:

CV_i = coefficient of variation for RF_i ,

SD_i = standard deviation for RF_i , and

Avg_i = average RF of impurity *i*.

12.7 The coefficient of variation for the response factor of any impurity, as calculated from a minimum of three successive analyses of the standard, shall not exceed 10 %.

13. Procedure

13.1 Bring the sample and calibration mixtures to identical temperatures, preferably 25°C. Make sure that the temperature of the sample is consistent with that of the calibration standard prepared in Section 12.

13.2 Depending upon the actual chromatograph's operating conditions, inject an appropriate amount of sample into the instrument. The injection amount shall be identical to the amount used in 12.3 and must be consistent with those conditions used to meet the criteria in 12.7.

13.3 Measure the area of all peaks except the major component(s). Measurements on the sample must be consistent with those made on the calibration blend. The nonaromatic fraction includes all peaks up to toluene (except for the peak assigned as benzene). Sum together all the nonaromatic peaks and report as a total area. The C_o aromatics fraction includes cumene and all peaks emerging after *o*-xylene, with exception of PDEB. Sum together all the C_o aromatic peaks and report as a total area. If PDEB is included in the calibration, report PDEB.