



Standard Test Method for Analysis of Styrene by Capillary Gas Chromatography¹

This standard is issued under the fixed designation D5135; 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.

^{ε1} NOTE—Table 3 was editorially corrected in November 2016.

1. Scope*

1.1 This test method covers the determination of the impurities typically found in styrene and uses those values to determine the purity of styrene by difference by gas chromatography. Typical impurities in commercial styrene are found in [Table 1](#).

1.2 This test method is applicable to impurity concentrations in the range of 0.001 to 1.00 % and for styrene purities of 99 % or higher when using the internal standard procedure.

1.3 In determining the conformance of the test results using this method to applicable specifications, results shall be rounded off in accordance with the rounding-off method of Practice [E29](#).

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

1.5 *This standard does not purport to address all 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 a specific hazard statement, see Section [9](#).

2. Referenced Documents

2.1 ASTM Standards:²

[D3437 Practice for Sampling and Handling Liquid Cyclic Products](#)

[D4307 Practice for Preparation of Liquid Blends for Use as Analytical Standards](#)

[D4790 Terminology of Aromatic Hydrocarbons and Related Chemicals](#)

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 [D16.07](#) on Styrene, Ethylbenzene and C9 and C10 Aromatic Hydrocarbons.

Current edition approved June 1, 2016. Published October 2016. Originally approved in 1990. Last previous edition approved in 2014 as D5135 – 14. DOI: 10.1520/D5135-16E01.

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.

[D6809 Guide for Quality Control and Quality Assurance Procedures for Aromatic Hydrocarbons and Related Materials](#)

[E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications](#)

[E355 Practice for Gas Chromatography Terms and Relationships](#)

[E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method](#)

[E1510 Practice for Installing Fused Silica Open Tubular Capillary Columns in Gas Chromatographs](#)

2.2 Other Document

[OSHA Regulations, 29 CFR paragraphs 1910.1000 and 1910.1200](#)³

3. Terminology

3.1 See Terminology [D4790](#) for definitions of terms used in this test method.

4. Summary of Test Method

4.1 In this test method, the chromatogram peak area for each impurity is compared to the peak area of the internal standard (*n*-heptane or other suitable known) added to the sample. From the response factors of these impurities relative to that of the internal standard and the amount of internal standard added, the concentration of the impurities are calculated. The styrene content is obtained by subtracting the total amount of all impurities from 100.00.

5. Significance and Use

5.1 This test method is designed to obtain styrene purity on the basis of impurities normally present in styrene and may be used for final product inspections and process control.

5.2 This test method will detect the impurities shown in [Table 1](#), non-aromatic hydrocarbons containing ten carbons or less, and others where specific impurity standards are available. Absolute purity cannot be determined if unknown impurities are present.

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>.

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

TABLE 1 Impurities Known or Suggested to be Present in Commercial Styrene

Ethylbenzene
o-xylene
m-xylene
p-xylene
Isopropylbenzene
n-propylbenzene
m-ethyltoluene
p-ethyltoluene
α-methylstyrene
m-vinyltoluene
p-vinyltoluene
Phenylacetylene

TABLE 2 Recommended Operating Conditions

Carrier gas	helium
Carrier gas flow rate at 110°C, mL/min	1.2
Detector	flame ionization
Detector temperature, °C	240
Injection port temperature, °C	230
Hydrogen flow rate, mL/min	30
Air flow rate, mL/min	275
Make up gas	nitrogen
Make up gas flow rate, mL/min	23
Split flow, mL/min	150
Column	60 m × 0.32 mm ID × 0.5 μm bonded polyethylene glycol-fused silica capillary
Column temperature, °C	110
Chart speed, cm/min	1
Sample size, μL	0.6

6. Interferences

6.1 The internal standard chosen must be satisfactorily resolved from any impurity as well as the product peak. A peak will be satisfactorily resolved from a neighboring peak if the distance from the valley to the baseline between the two peaks is not greater than 50 % of the peak height of the smaller of the two peaks.

7. Apparatus

7.1 *Gas Chromatograph*—Any instrument having a flame ionization detector that can be operated at the conditions given in [Table 2](#). 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 *Column*—A capillary column containing a stationary phase of cross-linked polyethylene glycol has been found to be satisfactory. Any column can be used that is capable of resolving all significant impurities from styrene and from the internal standard. 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 2](#) have been used successfully and shall be used as a referee in cases of dispute.

7.2.1 “Total non-aromatics” are defined as all components eluting before *o*-xylene, excluding benzene, toluene, ethylbenzene, *p*-xylene, *m*-xylene, and cumene. The internal standard used for calibration is also excluded. Generally, non-aromatics are summed and reported as a group. In certain cases, one or more individual non-aromatic components, such

as 1,4-dioxane, may be reported separately. In those cases, the grouping would not include the separately reported component(s), and the remaining non-aromatics would be reported as “Nonaromatics other than (component(s)).”

7.2.2 “Total C9-plus aromatics” are defined as cumene, plus all components eluting after *o*-xylene. Generally, C9-plus aromatics are summed and reported as a group. In certain cases, one or more individual C9-plus aromatic components, such as cumene or *p*-diethylbenzene, may be reported separately. In those cases, the grouping would not include the separately reported component(s) and the remaining C9-plus aromatics would be reported as “C9-plus aromatics other than (component(s)).” Very heavy non-aromatics may also elute in this region, but they are not common in materials within the scope of Committee D16, and are not considered in the definition.

7.3 *Recorder*—Electronic integration, with tangent capabilities is recommended.

7.4 *100-mL Volumetric Flask*.

7.5 *Microsyringes*, assorted volumes.

8. Reagents and Materials

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*, makeup and detector gases 99.999 % purity. Oxygen in carrier gas less than 1 ppm, less than 0.5 ppm is preferred. Purify carrier, makeup and detector gases to remove oxygen, water, and hydrocarbons.

8.3 *Air*, purify to remove hydrocarbons and water. Air should contain less than 0.1 ppm THC.

8.4 *n-Heptane*, 99.0 % minimum purity, or other internal standard, such as *n*-octane, previously analyzed to be free of compounds coeluting with impurities in the sample.

8.5 *Styrene*, the highest purity available, but not less than 99.7 %.

8.6 *Pure Compounds*, for calibration, shall be those compounds that are typically present in commercial styrene. These should be at least 99 % pure as they are to be used for determining response factors.

9. Hazards

9.1 Consult current OSHA regulations, suppliers’ Safety Data Sheets, and local regulations for all materials used in this procedure.

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.

10. Sampling

10.1 Sample the material in accordance with Practice [D3437](#).

11. Preparation of Apparatus

11.1 Follow manufacturer's instructions for mounting and conditioning the column into the chromatograph and adjusting the instrument conditions described in [Table 2](#), allowing sufficient time for the equipment to reach equilibrium. See Practices [E355](#) and [E1510](#) for additional information on gas chromatographic practices and terminology.

12. Calibration

12.1 Prepare a calibration mixture containing approximately 99.5 weight % styrene and the expected significant impurities at their expected concentration (see Practice [D4307](#)). Weigh all components to the accuracy required to calculate the concentration of each to the nearest 0.001 %.

12.2 With a microsyringe, add 50 μL of internal standard to a 100-mL volumetric flask about three-fourths full of calibration mixture. Mix well. Add calibration mixture to mark and again mix well. If *n*-heptane is used as the internal standard, using a density of 0.684 for *n*-heptane and 0.906 for styrene, this solution will contain 0.0377 weight % *n*-heptane.

12.3 Also prepare a sample of the styrene used for the calibration blend with and without *n*-heptane to determine the concentration of existing impurities and interfering compounds with internal standard. If impurities in the styrene emerge with the chosen internal standard, an alternate internal standard must be used.

12.4 Inject an appropriate amount of sample into the chromatograph and obtain a chromatogram.

12.5 Measure the areas of all peaks, including the internal standard, except the styrene peak.

12.6 Calculate the response factors for each impurity relative to the internal standard as follows:

$$RF_i = \frac{C_i}{(C_s) \left(\frac{A_i}{A_{si}} - \frac{A_b}{A_{sb}} \right)} \quad (1)$$

where:

- RF_i = response factor relative to the internal standard,
- A_{si} = area of internal standard in calibration mixture,
- A_i = area of impurity peak in calibration mixture,
- A_{sb} = area of internal standard in styrene used in making calibration mixture,
- A_b = area of impurity in styrene used to make calibration mixture,
- C_s = weight percent internal standard in calibration mixture, and
- C_i = weight percent impurity in calibration mixture.

13. Procedure

13.1 Establish stable instrument operation at the prescribed or selected operating conditions. Reference should be made to instructions provided by the manufacturer of the chromatograph.

13.2 Prepare sample as described in [12.2](#).

13.3 Inject appropriate amount of sample into the chromatograph and obtain the chromatogram. A typical chromatogram is shown in [Fig. 1](#).

14. Calculation

14.1 Measure the areas of all peaks, including the internal standard, except the styrene peak.

14.2 Calculate the weight percent of the individual impurities, C_i , as follows:

$$C_i = \frac{(A_i) (RF_i) (C_s)}{A_s} \quad (2)$$

where:

- A_i = area of impurity,
- A_s = area of internal standard,
- RF_i = response factor for impurity, relative to the internal standard, and
- C_s = concentration of internal standard, in weight percent.

14.3 Calculate the styrene content by subtracting the sum of the impurities from 100.00. Styrene weight percent = 100.00 – (sum of impurities).

15. Report

15.1 Report the concentration of impurities to the nearest 0.001 % and the styrene content to the nearest 0.01 %.

16. Precision and Bias⁵

16.1 *Precision*—The following criteria should be used to judge the acceptability (95 % probability level) of results obtained by this test method (see Practice [E691](#)).

16.1.1 The criteria presented in [Table 3](#) and [Table 4](#) were derived from a Interlaboratory Study (ILS) among six laboratories. The data were run on two days using different operators.

16.1.2 The criteria and precision data presented in [Table 5](#) were derived from a commercial Proficiency Testing scheme performed during the years 1997 through 2014 (no formal PT report available, however data are available to ASTM).

16.2 *Intermediate Precision (formerly called Repeatability)*—Results in the same laboratory should not be considered suspect unless they differ by more than the normal amount shown in [Table 3](#) and [Table 4](#).

16.3 *Reproducibility*—The results by each of two laboratories should not be considered suspect unless they differ by more than the amount shown in [Table 3](#), [Table 4](#) and [Table 5](#).

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D16-1031. Contact ASTM Customer Service at service@astm.org.

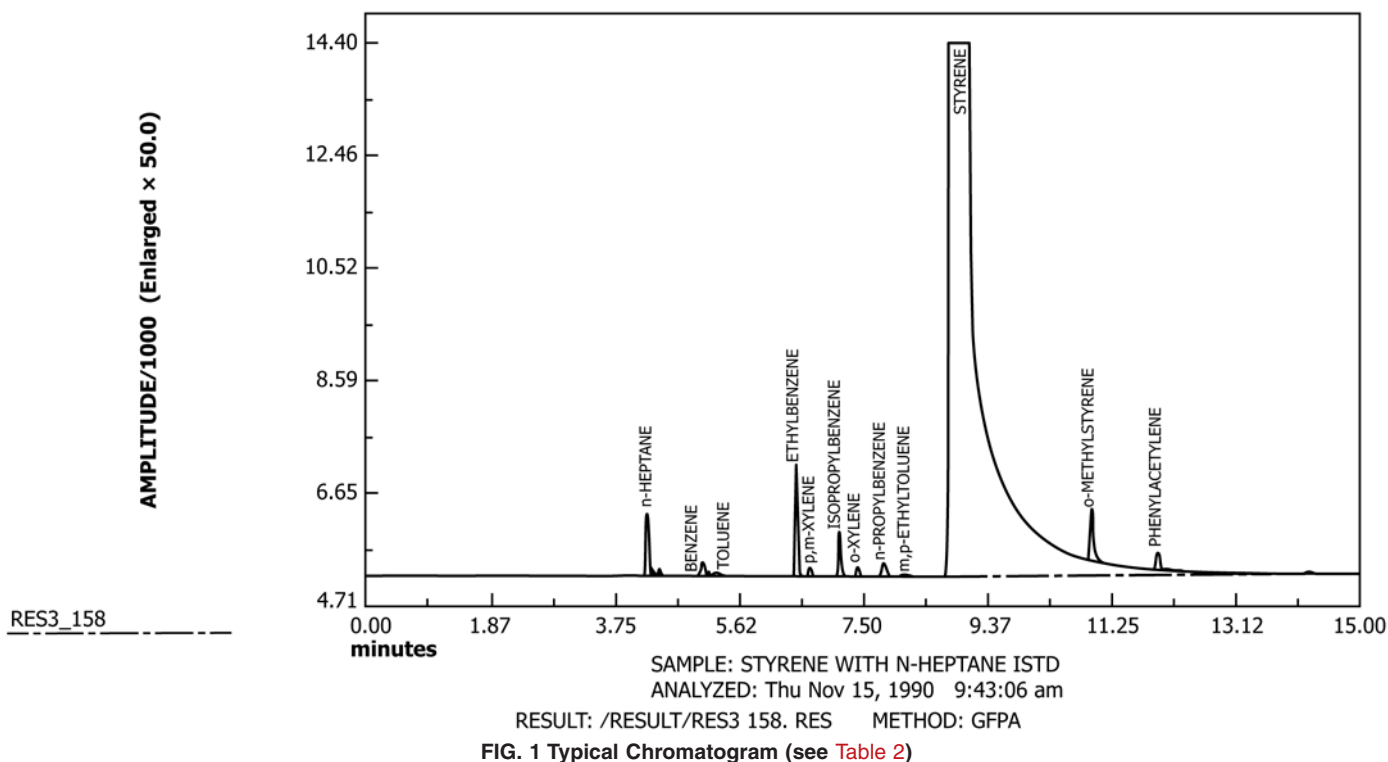


TABLE 3 ILS Precision for Styrene and Impurities at Stated Levels

Component	Concentration, weight %	Intermediate Precision, weight %	Reproducibility, weight %
Styrene	99.74	0.017	0.054
α -methylstyrene	0.028	0.001†	0.004
Isopropylbenzene	0.008	0.001	0.001
<i>n</i> -propylbenzene	0.004	0.0003	0.001
<i>m</i> - and <i>p</i> -ethyltoluene	0.014	0.001	0.005
<i>p</i> , <i>m</i> -xylene	0.125	0.005	0.007
<i>o</i> -xylene	0.030	0.001	0.042

† Editorially corrected.

TABLE 4 ILS Precision for High Purity Styrene and Impurities at Stated Levels

Component	Concentration, weight %	Intermediate Precision, weight %	Reproducibility, weight %
Styrene	99.96	0.024	0.033
Ethylbenzene	0.014	0.003	0.004
α -methylstyrene	0.007	0.002	0.003

TABLE 5 PT Precision for High Purity Styrene and Impurities at Stated Levels

Component	Concentration Average, weight %	Concentration range tested, weight %	Reproducibility at the average, weight %
Styrene	99.93	99.84 - 99.96	0.028
Benzene	0.0007	0.0002 - 0.0018	0.0003
Ethylbenzene	0.010	0.006 - 0.023	0.001
<i>m</i> , <i>p</i> -Xylenes	0.007	0.0004 - 0.041	0.002
Cumene	0.010	0.0013 - 0.022	0.002
<i>o</i> -Xylene	0.004	0.0006 - 0.013	0.001
<i>n</i> -propylbenzene	0.004	0.0005 - 0.006	0.001
<i>m</i> , <i>p</i> -Ethyltoluene	0.002	0.0005 - 0.003	0.001
Phenylacetylene	0.001	0.0006 - 0.009	0.001
Benzaldehyde	0.008	0.003 - 0.011	0.003
Non-aromatics	0.006	0.0010 - 0.015	0.007
α -Methylstyrene	0.022	0.0095 - 0.045	0.004

16.4 *Bias*—Bias of this test method for the analysis of styrene has not been determined because no acceptable reference material is available.

17. Quality Guidelines

17.1 Laboratories shall have a quality control system in place.

17.1.1 Confirm the performance of the test instrument or test method by analyzing a quality control sample following the guidelines of standard statistical quality control practices.

17.1.2 A quality control sample is a stable material isolated from the production process and representative of the sample being analyzed.

17.1.3 When QA/QC protocols are already established in the testing facility, these protocols are acceptable when they confirm the validity of test results.

17.1.4 When there are no QA/QC protocols established in the testing facility, use the guidelines described in Guide D6809 or similar statistical quality control practices.

18. Keywords

18.1 analysis by gas chromatography; impurities in styrene; purity of styrene; styrene; styrene monomer

SUMMARY OF CHANGES

Committee D16 has identified the location of selected changes to this standard since the last issue (D5135–14) that may impact the use of this standard. (Approved June 1, 2016.)

(1) Section 16 — added precision values based on Proficiency Test (PT) data.

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