



Designation: D7892 – 22

Standard Test Method for Determination of Total Organic Halides, Total Non-Methane Hydrocarbons, and Formaldehyde in Hydrogen Fuel by Gas Chromatography/Mass Spectrometry¹

This standard is issued under the fixed designation D7892; 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 The gas chromatography/mass spectrometry (GC/MS) procedure described in this test method is used to determine concentrations of total organic halides and total non-methane hydrocarbons (TNMHC) in hydrogen by measurement of individual target halocarbons (Table 1) and hydrocarbons (including formaldehyde, Table 1 and Table 2), respectively.

1.2 Mention of trade names in this test method does not constitute endorsement or recommendation for use. Other manufacturers' equipment or equipment models can be used.

1.3 *Units*—The values stated in SI units are to be regarded as standard.

1.4 *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.*

1.5 *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

D4150 Terminology Relating to Gaseous Fuels

D7606 Practice for Sampling of High Pressure Hydrogen and Related Fuel Cell Feed Gases

2.2 SAE Standard:³

SAE J2719 Hydrogen Fuel Quality for Fuel Cell Vehicles

3. Terminology

3.1 *Definitions*—For definitions of general terms used in D03 Gaseous Fuels standards, refer to Terminology D4150.

3.2 Abbreviations:

3.2.1 GC—gas chromatograph

3.2.2 *m/e*—mass to charge ratio

3.2.3 MS—mass spectrometer

3.2.4 *ppb(v)*—parts per billion as a volume

3.2.5 *ppm(v)*—parts per million as a volume

3.2.6 UHP—ultra high purity

4. Summary of Test Method

4.1 The target compounds in Table 1 and Table 2, which may be contained in a 400 mL hydrogen sample, are cryogenically frozen or concentrated onto a glass bead trap at -150 °C. The target compounds are slowly desorbed by warming to 10 °C and transferred to a Tenax trap cooled to -60 °C using desorption flow rate of 10 mL/min. This process leaves water in the glass bead trap and dehydrates the sample. The Tenax trap is then desorbed by heating to 180 °C and the target compounds cyro-focused at -170 °C at the entrance to a GC column (see 6.5). The cyro-focusing section is then rapidly heated up to 80 °C to release the cryo-focused target compounds, which are eventually eluted from the column and analyzed using a mass spectrometer scanning from *m/e* 23 to 100 for initial 4.5 min and from *m/e* 34 to 550 the remaining analytical time. The retention times of the target compounds are listed in Table 1 and Table 2 under the chromatographic conditions in 6.5.

5. Significance and Use

5.1 Low operating temperature fuel cells such as PEMFCs require high purity hydrogen for optimal performance and

¹ This test method is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.14 on Hydrogen and Fuel Cells.

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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 Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

TABLE 1 Organic Halides

Target Compounds	Formulas	MW	BP°C	MP°C	CAS No.	Retention Time (min)
1,1,1-Trichloroethane	C ₂ H ₃ Cl ₃	133.4	74	-33	71-55-6	8.876
1,1,2,2-Tetrachloroethane	C ₂ H ₂ Cl ₄	167.9	147	-44	79-34-5	14.627
1,1,2-Trichloroethane	C ₂ H ₃ Cl ₃	133.4	114	-37	79-00-5	11.607
1,2-Dibromoethane	C ₂ H ₄ Br ₂	187.9	132	10	106-93-4	12.555
1,1-Dichloroethane	C ₂ H ₄ Cl ₂	99	57	-97	75-34-3	7.034
1,1-Dichloroethene	C ₂ H ₂ Cl ₂	96.9	32	-122	75-35-4	5.927
1,2,4-Trichlorobenzene	C ₆ H ₃ Cl ₃	181.5	214	17	120-82-1	19.795
1,2,3,4-tetrachlorohexafluorobutane	C ₄ Cl ₄ F ₆	303.4	134	0 dl; 73 meso	375-45-1	13.008
1,2-Dichloroethane	C ₂ H ₄ Cl ₂	99	84	-35	107-06-2	8.658
1,2-Dichloropropane	C ₃ H ₆ Cl ₂	113	96	-100	78-87-5	10.006
1,2-Dichlorobenzene	C ₆ H ₄ Cl ₂	147	181	-17	95-50-1	17.334
1,3-Dichlorobenzene	C ₆ H ₄ Cl ₂	147	173	-24	541-73-1	16.799
1,4-Dichlorobenzene	C ₆ H ₄ Cl ₂	147	174	54	106-46-7	16.881
Benzyl Chloride	C ₇ H ₇ Cl	126.6	179	-39	100-44-7	16.769
Bromodichloromethane	CHBrCl ₂	162	90	-57	75-27-4	10.189
Bromoform	CHBr ₃	252.7	149	8	75-25-2	14.303
Bromomethane	CH ₃ Br	94.9	4	-94	74-83-9	4.326
Carbon tetrachloride	CCl ₄	153.8	77	-23	56-23-5	9.418
Chlorobenzene	C ₆ H ₅ Cl	112.6	131	-45	108-90-7	13.626
Chloroethane	C ₂ H ₅ Cl	64.5	12	-139	75-00-3	4.52
Chloroform	CHCl ₃	119.4	61	-64	67-66-3	7.987
Chloromethane	CH ₃ Cl	50.5	5	-24	74-87-3	3.504
cis-1,2-dichloroethene	C ₂ H ₂ Cl ₂	97	60	-81	156-59-2	7.728
cis-1,3-Dichloropropene	C ₃ H ₄ Cl ₂	111	104	-85	10061-01-5	10.948
Dibromochloromethane	CHBr ₂ Cl	208.3	119	-22	124-48-1	12.308
Dichlorodifluoromethane	CCl ₂ F ₂	120.9	-30	-158	75-71-8	3.251
Freon113 (1,1,2-Trichloro-1,2,2-trifluoroethane)	C ₂ Cl ₃ F ₃	187.4	48	-35	76-13-1	6.239
Freon114 (1,2-Dichlorotetrafluoroethane)	C ₂ Cl ₂ F ₄	170.9	4	-94	76-14-2	3.641
Hexachlorobutadiene	C ₄ Cl ₆	260.8	210–220	-22 to -19	87-68-3	20.56
Methylene chloride	CH ₂ Cl ₂	84.9	40	-97	75-09-2	6.015
Tetrachloroethene	C ₂ Cl ₄	165.8	121	-19	127-18-4	12.943
trans-1,2-dichloroethene	C ₂ H ₂ Cl ₂	97	48	-81	156-60-5	6.839
trans-1,3-Dichloropropene	C ₃ H ₄ Cl ₂	110	112	-85	10061-02-6	11.401
Trichloroethene	C ₂ HCl ₃	131.4	87	-73	79-01-6	10.177
Trichlorofluoromethane	CCl ₃ F	137.4	23	-111	75-69-4	5.321
Vinyl Chloride	C ₂ H ₂ Cl ₂	62.5	-13	-154	75-01-4	3.8

TABLE 2 Non-Halogenated Non-Methane Hydrocarbons

Target Compounds	Formula	MW	BP°C	MP°C	CAS No.	Retention Time (min)
1,2,4-Trimethylbenzene	C ₉ H ₁₂	120.20	169	-44	95-63-6	16.557
1,3,5-Trimethylbenzene	C ₉ H ₁₂	120.20	165	-45	108-67-8	16.045
1,3-Butadiene	C ₄ H ₆	54.09	-4	-109	106-99-0	3.985
1,4-Dioxane	C ₄ H ₈ O ₂	88.11	101	12	123-91-1	10.601
2-Butanone	C ₄ H ₈ O	72.11	80	-86	78-93-3	7.516
2-Hexanone	C ₆ H ₁₂ O	100.16	128	-56	591-78-6	12.325
4-Ethyltoluene	C ₉ H ₁₂	120.19	162	-62	622-96-8	15.969
4-Methyl-2-Pentanone	C ₆ H ₁₂ O	100.16	117–118	-85	108-10-1	11.154
Acetone	C ₃ H ₆ O	58.08	56–57	-95 to -93	67-64-1	5.356
Ethene	C ₂ H ₄	28.05	-104	-169	9002-88-4	2.771
Benzene	C ₆ H ₆	78.11	80	6	71-43-2	9.294
Cyclohexane	C ₆ H ₁₂	84.16	81	6	110-82-7	9.529
Ethane	C ₂ H ₆	30.07	-89	-183	74-84-0	2.82
Ethanol	C ₂ H ₆ O	46.07	78	-114	64-17-5	5.556
Ethyl Acetate	C ₄ H ₈ O ₂	88.11	77	-84	141-78-6	7.958
Ethylbenzene	C ₈ H ₁₀	106.17	136	-95	100-41-4	13.962
Formaldehyde	CH ₂ O	30.03	-19	-92	50-00-0	3.025
Heptane	C ₇ H ₁₆	100.2	98–99	-91 to -90	142-82-5	10.342
Hexane	C ₆ H ₁₄	86.18	68–69	-96 to -94	110-54-3	7.875
Isopropyl Alcohol	C ₃ H ₈ O	60.1	83	-89	67-63-0	6.38
Methyl tert-Butyl Ether	C ₅ H ₁₂ O	88.15	55	-109	1634-04-4	7.199
Propane	C ₃ H ₈	44.1	-42	-188	74-98-6	3.173
Propene	C ₃ H ₆	42.08	-48	-185	115-07-1	3.137
Styrene	C ₈ H ₈	104.16	145	-31	100-42-5	14.503
Tetrahydrofuran	C ₄ H ₈ O	72.11	66	-108	109-99-9	8.529
Toluene	C ₇ H ₈	92.15	111	-95	108-88-3	11.866
Vinyl acetate	C ₄ H ₆ O ₂	86.09	73	-93	108-05-4	7.134
Xylenes, m&p-	C ₈ H ₁₀	106.17	139(m) 138(p)	-48(m) 13(p)	108-38-3(m) 106-42-3(p)	14.132
Xylenes, o-	C ₈ H ₁₀	106.16	144	-24	95-47-6	14.638