Designation: D3343 – 22

Standard Test Method for Estimation of Hydrogen Content of Aviation Fuels[1]

This standard is issued under the fixed designation D3343; 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 test method covers the estimation of the hydrogen content (mass percent) of aviation gasolines and aircraft turbine and jet engine fuels.

1.2 This test method is empirical and is applicable to liquid hydrocarbon fuels that conform to the requirements of specifications for aviation gasolines or aircraft turbine and jet engine fuels of types Jet A, Jet A-1, Jet B, JP-4, JP-5, JP-7, and JP-8.

NOTE 1—The procedure for the experimental determination of hydrogen in petroleum fractions is described in Test Methods D1018, D3701, D5291, and D7171.

NOTE 2—The estimation of the hydrogen content of a hydrocarbon fuel is justifiable only when the fuel belongs to a well-defined class for which a relationship among the hydrogen content and the distillation range, density, and aromatic content has been derived from accurate experimental measurements on representative samples of that class. Even in this case, the possibility that the estimates may be in error by large amounts for individual fuels should be recognized. The fuels used to establish the correlation presented in this test method are defined by the following specifications:

Fuel	Specification
Aviation gasolines	D910
Aircraft turbine and jet engine fuels	
JP-4 and JP-5	MIL-DTL-5624
JP-7	MIL-DTL-38219
JP-8	MIL-DTL-83133
Jet A and Jet A-1	D1655
Miscellaneous hydrocarbons	
No. 2 Diesel fuel	
Kerosene distillates (similar to Jet A)	
Miscellaneous (includes thinners, gasoline fractions, and unidentified blends)	
Special production fuels (commercial products of nearly pure hydrocarbons and special high-temperature fuels (HTF) produced for Air Force tests.	
Pure hydrocarbons	

1.3 The values stated in SI units are to be regarded as the standard.

1.3.1 *Exception*—The values given in parentheses are for information only.

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]

D86 Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

D910 Specification for Leaded Aviation Gasolines

D1018 Test Method for Hydrogen In Petroleum Fractions (Withdrawn 2021)[3]

D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

D1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption

D1655 Specification for Aviation Turbine Fuels

D2887 Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography

D3701 Test Method for Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry

D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants

D5291 Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants

D7171 Test Method for Hydrogen Content of Middle Distillate Petroleum Products by Low-Resolution Pulsed Nuclear Magnetic Resonance Spectroscopy

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.04.0K on Correlative Methods.

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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] The last approved version of this historical standard is referenced on www.astm.org.

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

2.2 *Military Specifications:*[4]

MIL-DTL-5624 Turbine Fuel, Aviation, Grade JP-4 and JP-5

MIL-DTL-38219 Turbine Fuel, Low Volatility, JP-7

MIL-DTL-83133 Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37)

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Terminology D4175.

4. Summary of Test Method

4.1 A correlation[5] has been established between the hydrogen content of a fuel and its distillation range, API gravity, and aromatic content. This relationship is given by the following equations:

Type fuel—All aviation gasolines and aircraft turbine fuels

$$\%\ \mathrm{H} = 0.063\,17G - 0.041\,089A + 0.000\,072\,135AV + 0.000\,056\,84GV - 0.000\,496\,0GA + 10.56 \quad (1)$$

or in SI Units,[6]

$$\%\ \mathrm{H} = (9201.2 + 14.49T - 70.22A)/D + 0.026\,52A + 0.000\,129\,8AT - 0.013\,47T + 2.003 \quad (2)$$

where:

- % H = mass percent hydrogen;
- G = gravity, °API;
- A = volume percent aromatics;
- V = average of 10 %, 50 %, and 90 % distillation data, °F (using Test Method D86);
- T = average of 10 %, 50 %, and 90 % distillation data, °C; and
- D = density in kg/m^3 at 15 °C.

4.2 Eq 1 was empirically derived for the mass percent hydrogen by the method of least squares from accurate data on fuels using inch-pound units of measurement. Eq 2 was derived directly from Eq 1 by simply converting from inch-pound to SI units of measurement.

5. Significance and Use

5.1 This test method is intended for use as a guide in cases in which an experimental determination of hydrogen content is not available. Table 1 shows a summary for the range of each variable used in developing the correlation. The mean value and its distribution about the mean, namely the standard deviation, is shown. This indicates, for example, that the mean density for all fuels used in developing the correlation was 783.5 kg/m^3 and that two thirds of the samples had a density between 733.2 kg/m^3 and 841.3 kg/m^3, that is, plus and minus one standard deviation. The correlation is most accurate when the values of the variables to be used in the equation are within one standard deviation of the mean, but is useful up to two standard deviations of the mean. The use of this correlation may be applicable to other hydrocarbon distillates similar to aviation fuels, but only limited data on nonaviation fuels were included in the correlation.

TABLE 1 Mean and Standard Deviation of the Variables

Variable	Mean	Standard Deviation
Aromatics, volume, %	14.1	21.6
Density, kg/m^3 (°API)	783 (49.1)	54 (12.4)
Volatility, °C (°F)	178 (352)	53 (96)
Mass percent hydrogen	14.1	1.3

5.2 Hydrogen content is required to correct gross heat of combustion to net heat of combustion. Net heat is used in aircraft calculation because all combustion products are in the gaseous state, but experimental methods measure gross heat.

6. Procedure

6.1 Determine the density or the API gravity of the fuel sample as described in Practice D1298–API 2547–IP 160.

6.2 Determine the temperatures at which 10 %, 50 %, and 90 % of the fuel are recovered using Test Method D86–IP 123 or Test Method D2887–IP 406. Average these three temperatures to obtain the T value (in °C) or the V value (in °F) used in the equations of 4.1.

NOTE 3—Distillation data (10 %, 50 %, and 90 %) obtained by Test Method D2887 are not equivalent to the same data obtained by Test Method D86. However, as the 50 % temperatures are approximately equal, and the 90 % delta is similar in magnitude and opposite in sign to the 10 % delta, the average of the 10 %, 50 %, and 90 % temperatures by either test method may be used to estimate hydrogen content by Test Method D3343.

6.3 Determine the aromatic volume percent of the sample using Test Method D1319–IP 156.

7. Calculation and Report

7.1 *Inch-Pound Units*—Calculate the percent hydrogen of the sample using Eq 1 in 4.1. Round the value obtained to the nearest 0.01 %.

Example: Sample: Aviation kerosene fuel

Determined Values:

API gravity, G = 44

Aromatic volume percent, A = 12

Average distillation temperature, V = 400 °F (10 % = 350 °F, 50 % = 390 °F, 90 % = 460 °F; V = (350 + 390 + 460)/3 = 400 °F

Using Eq 1 in 4.1:

$$\%\ \mathrm{H} = 0.063\,17(44) - 0.041\,089(12) + 0.000\,072\,135(12)\,(400) + 0.000\,056\,84(44)\,(400) - 0.000\,496\,0(44)\,(12) + 10.56 \quad (3)$$

$$\%\ \mathrm{H} = 13.9311 = 13.93$$

[4] Copies of these documents are available online at http://www.quicksearch.dla.mil.

[5] Bert, J. A., and Painter, L. J., "Method for Calculating Hydrogen Content of Aviation Fuels," Chevron Research Co., Richmond, CA, Jan. 12, 1973.

[6] Supporting data (conversion of Eq 1 to SI units) have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1266. Contact ASTM Customer Service at service@astm.org.