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

This standard is issued under the fixed designation D 3343; 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 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 D 1018 and D 3701.

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 method are defined by the following specifications:

Fuel	Specification
Aviation gasolines	D 910
Aircraft turbine and jet engine fuels	
JP-4 and JP-5	MIL-T-5624
JP-6	MIL-J-25056 (Obsolete)
JP-7	MIL-T-38219
Jet A	D 1655
Miscellaneous hydrocarbons	
No. 2 Diesel fuel	
Kerosine 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. The values given in parentheses are for information only.

1.4 *This standard does not purport to address 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 86 Test Method for Distillation of Petroleum Products at Atmospheric Pressure[2]

D 910 Specification for Aviation Gasolines[2]

D 1018 Test Method for Hydrogen in Petroleum Fractions[2]

D 1298 Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method[2]

D 1319 Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption[2]

D 1655 Specification for Aviation Turbine Fuels[2]

D 3701 Test Method for Hydrogen Content of Aviation Turbine Fuels by Low Resolution Nuclear Magnetic Resonance Spectrometry[3]

2.2 *Military Standards:*

MIL-T-5624 Specification for Turbine Fuel, Aviation, Grade JP-4 and JP-5[4]

MIL-J-25056 Specification for Turbine Fuel, Grade JP-6[4]

MIL-T-38219 Specification for Turbine Fuel, Low Volatility, JP-7[4]

3. Summary of Test Method

3.1 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

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

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

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[2] *Annual Book of ASTM Standards*, Vol 05.01.

[3] *Annual Book of ASTM Standards*, Vol 05.02.

[4] Available from Standardization Documents, Order Desk, Bldg. 4, Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, ATTN: NPODS.

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

or in SI Units,[6]

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

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 D 86);
T	=	average of 10, 50, and 90 % distillation data, °C; and
D	=	density in kg/m^3 at 15°C.

3.2 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.

4. Significance and Use

4.1 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 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.

4.2 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.

5. Procedure

5.1 Determine the density or the API gravity of the fuel sample as described in Practice D 1298 – API 2547 – IP 160.

5.2 Determine the temperatures at which 10, 50, and 90 % of the fuel are recovered using Test Method D 86 – IP 123. Average these three temperatures to obtain the T value (in °C) or the V value (in °F) used in the equations of 3.1.

5.3 Determine the aromatic volume percent of the sample using Test Method D 1319 – IP 156.

6. Calculation and Report

6.1 *Inch-Pound Units*—Calculate the percent hydrogen of the sample using Eq 1 in 3.1. Round the value obtained to the nearest 0.01 %.

Example: Sample: Aviation kerosine 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 3.1:

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

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

6.2 *SI Units*—Calculate the percent hydrogen of the sample using Eq 2 of 3.1. Round the value obtained to the nearest 0.01 %.

Example: Sample: Aviation kerosine fuel

Determined Values:

Density, D = 805.9 kg/m^3

Aromatics, volume %, A = 12

Average distillation temperature, T = 205°C (10 % = 178°C, 50 % = 200°C, 90 % = 237°C, T = (178 + 200 + 237)/3 = 205°C)

Using Eq 2 in 3.1.

$$\% \text{ H} = [9201.2 + 14.49(205) - 70.22(12)]/805.9 + 0.026\,52(12) + 0.000\,129\,8(12)\,(205) - 0.013\,47(205) + 2.003 \quad (4)$$

$$\% \text{ H} = 13.9367 = 13.94$$

6.3 An alternative method for calculating the percent hydrogen is by summing the values of $F_1(H_2)$ and $F_2(H_2)$ determined from the nomographs in Fig. 1 and Fig. 2, respectively.

6.3.1 Determine the $F_1(H_2)$ value using the nomograph of Fig. 1. Enter the nomograph at the abscissa with the density or the API gravity value, then move vertically upward to the volume percent aromatics line, and then move horizontally to the left and read off the value of $F_1(H_2)$.

6.3.2 Determine the $F_2(H_2)$ value using the nomograph of Fig. 2. Enter the nomograph at the left ordinate using the density or the API gravity. Move horizontally to the right to the volume percent aromatics line, then vertically downward to the average boiling point line (average of the 10, 50, and 90 % distillation temperatures) using either °F or °C, and then horizontally to the right ordinate and read the $F_2(H_2)$ value.

6.3.3 Sum the $F_1(H_2)$ and the $F_2(H_2)$ values to obtain the estimated hydrogen content in mass percent.

6.4 Report the result from 6.1, 6.2, or 6.3 to the nearest 0.01 % as weight percent of hydrogen of the fuel sample.

[6] The conversion of Eq 1 to SI units is described in Research Report RR:D02-1266.

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

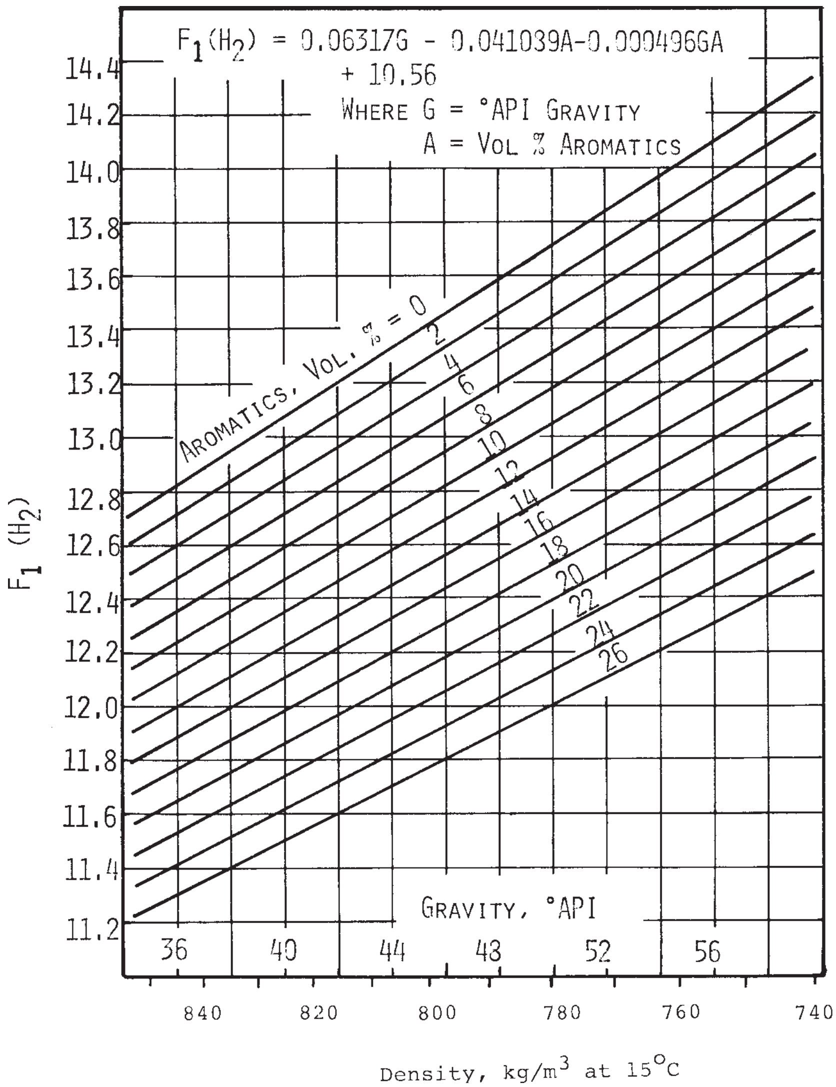

FIG. 1 Nomogram for Determining $F_1(H_2)$

7. Precision and Bias [7]

7.1 The following criteria should be used for judging the acceptability of estimated hydrogen content results (95 % confidence):

7.1.1 *Repeatability*—Duplicate results by the same operator (using a second set of measured values for aromatics content, density, and distillation data) should be considered suspect if the calculated hydrogen content values differ by more than the following amount:

$$\text{Repeatability} = 0.03\ \% \tag{5}$$

7.1.2 *Reproducibility*—With two independent laboratories making independent measurements of the density, aromatics content, and distillation data for an identical fuel sample, the calculated hydrogen content values should not be considered suspect unless they differ by more than the following amount:

$$\text{Reproducibility} = 0.10\ \% \tag{6}$$

7.2 *Bias*—The correlation equation was developed using 331 fuels, 247 of which were aviation fuels (or similar thereto) and 84 of which were pure hydrocarbons, commercial products of nearly pure hydrocarbons, and special high-temperature fuels (HTF) produced for Air Force tests. The standard error of estimate for the hydrogen content of all fuels is 0.20 % and for aviation type fuels is 0.16 %.

NOTE 3—The repeatability and reproducibility stated in this section is based on the summation of the repeatability and reproducibility of the test methods used in the calculations. It does not include the effect of the scatter of the original data about the regression line, described by Eq 1 and Eq 2. Therefore, the possibility that individual estimates may be in error in excess of the precision discussed in this section should be recognized.

8. Keywords

8.1 aviation fuels; hydrogen content

[7] Supporting data are available from ASTM Headquarters. Request RR: D02-1184.

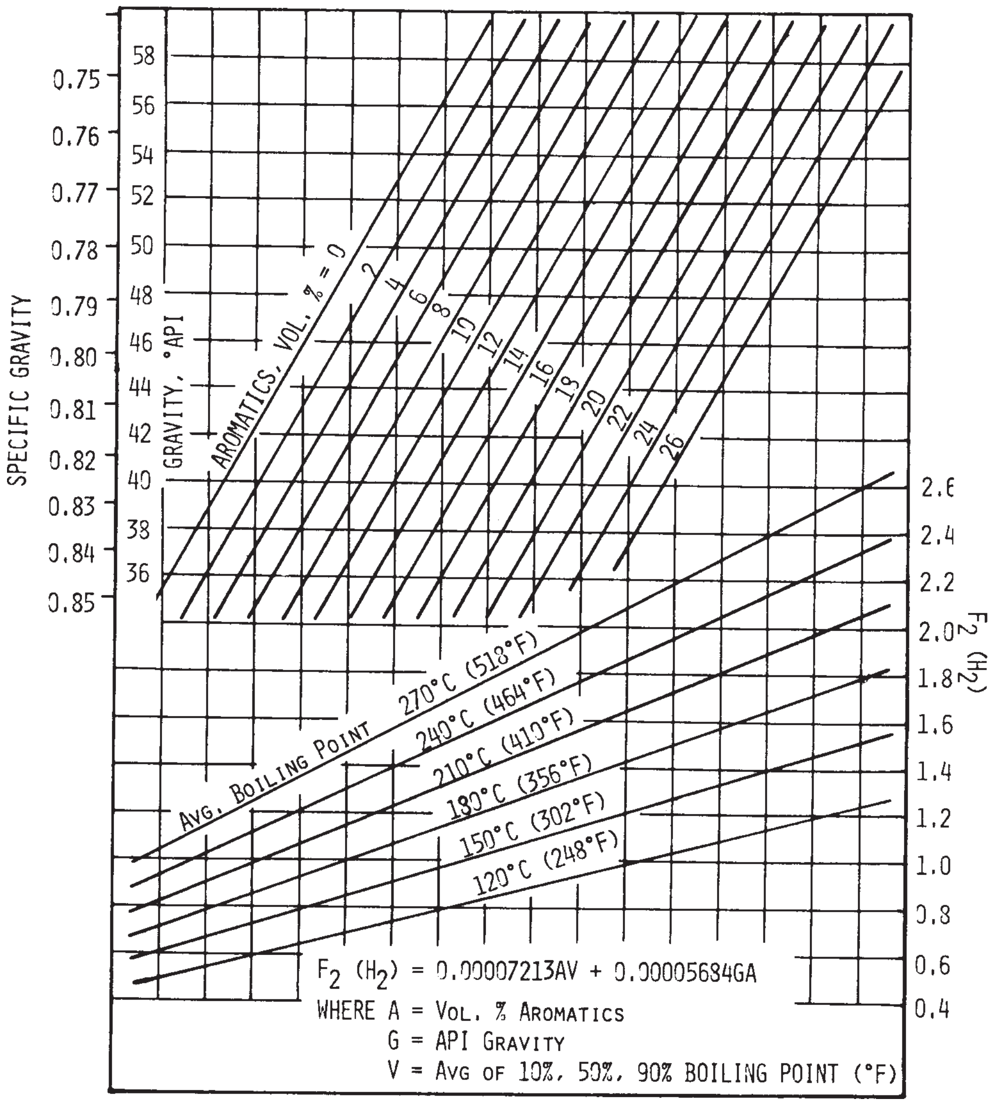

FIG. 2 Nomogram for Determining $F_2(H_2)$