



Designation: ~~D5188 – 14~~ **D5188 – 16**

## Standard Test Method for Vapor-Liquid Ratio Temperature Determination of Fuels (Evacuated Chamber and Piston Based Method)<sup>1</sup>

This standard is issued under the fixed designation D5188; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope\*

1.1 This test method covers the determination of the temperature at which the vapor formed from a selected volume of volatile petroleum product saturated with air at 0 °C to 1 °C (32 °F to 34 °F) produces a pressure of ~~101.3 kPa~~ **101.3 kPa** (one atmosphere) against vacuum. This test method is applicable to samples for which the determined temperature is between 36 °C and 80 °C (97 °F and 176 °F) and the vapor-liquid ratio is between 8 to 1 and 75 to 1.

NOTE 1—When the vapor-liquid ratio is 20:1, the result is intended to be comparable to the results determined by Test Method **D2533**.

NOTE 2—This test method may also be applicable at pressures other than one atmosphere, but the stated precision may not apply.

1.2 This test method is applicable to both gasoline and gasoline-oxygenate blends.

1.2.1 Some gasoline-oxygenate blends may show a haze when cooled to 0 °C to 1 °C. If a haze is observed in **12.5**, it shall be indicated in the reporting of results. The precision and bias statements for hazy samples have not been determined (see **Note 1012**).

1.3 The values stated in SI units are to be regarded as standard. ~~The values given in parentheses are provided for information only.~~

1.3.1 *Exception*—The values given in parentheses are provided 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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific warnings, see Section 7-27 and subsection 8.1.1.

### 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

**D2533** Test Method for Vapor-Liquid Ratio of Spark-Ignition Engine Fuels (Withdrawn 2008)<sup>3</sup>

**D2892** Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)

**D4057** Practice for Manual Sampling of Petroleum and Petroleum Products

**D6299** Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance

**D6708** Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material

### 3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1  $T_{(V/L = 20)}$ ,  $n$ —the equilibrium temperature at which the partial pressure of a sample under test conditions is equal to 101.3 kPa (14.69 psia) and the vapor-liquid ratio is 20.

3.1.2 *vapor-liquid ratio of a fuel, n*—the ratio at a specified temperature and pressure of the volume of vapor in equilibrium with liquid to the volume of sample charged, as a liquid, at 0 °C (32 °F).

<sup>1</sup> 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 **D02.08** on Volatility.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

<sup>3</sup> The last approved version of this historical standard is referenced on [www.astm.org](http://www.astm.org).

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

#### 4. Summary of Test Method

4.1 A known volume of chilled, air-saturated sample is introduced into an evacuated, thermostatically controlled test chamber of known volume or a test chamber with moveable piston that expands the volume after sample introduction, the internal volume of which is  $V/L+1$  times of that of the total test specimen introduced into the chamber. The sample volume is calculated to give the desired vapor-liquid ratio for the chamber volume in use. After injection, the chamber temperature is adjusted until a stable chamber pressure of 101.3 kPa (14.69 psia) is achieved.

#### 5. Significance and Use

5.1 The tendency of a fuel to vaporize in automotive engine fuel systems is indicated by the vapor-liquid ratio of the fuel.

5.2 Automotive fuel specifications generally include  $T_{(V/L=20)}$  limits to ensure products of suitable volatility performance. For high ambient temperatures, a fuel with a high value of  $T_{(V/L=20)}$ , indicating a fuel with a low tendency to vaporize, is generally specified; conversely for low ambient temperatures, a fuel with a low value of  $T_{(V/L=20)}$  is specified.

#### 6. Apparatus

6.1 Apparatus suitable for use shall employ a small volume test chamber incorporating a transducer for pressure measurements and associated equipment for thermostatically controlling the chamber temperature, evacuating the test chamber prior to sample introduction, or expanding the volume after sample introduction by a moveable piston, and cleaning and purging the chamber following the test. Critical elements of the apparatus shall meet the following specifications:

6.1.1 *Test Chamber*, constructed of stainless steel or aluminum, designed to contain between 5 mL and 50 mL of liquid plus vapor with a tolerance of  $\pm 1\%$  of the nominal capacity.

NOTE 3—The test chamber volumes of the instruments used for the 1991 cooperative test program to determine the precision and bias statements were between 5 mL and 15 mL of liquid plus vapor with a tolerance of  $\pm 1\%$  of the nominal capacity.

6.1.2 *Pressure Transducer*, minimum operational range from 1 kPa to 177 kPa (0 psia to 25.6 psia) with minimum resolution of 0.1 kPa (0.01 psi) and minimum accuracy of  $\pm 0.8$  kPa ( $\pm 0.12$  psi). The pressure measurement system shall include associated electronics and readout devices to display the resulting pressure reading.

6.1.3 *Heater*, thermostatically controlled heater capable of maintaining the test chamber within 0.1 °C of the set temperature for a minimum of 5 minutes.

NOTE 4—The use of automated instruments that automatically adjust the temperature, after sample injection, to give a pressure of 101.3 kPa (14.69 psia) is allowed.

6.1.4 *Platinum Resistance Thermometer*, used to measure the temperature of the test chamber, having a minimum temperature range of 36 °C to 80 °C, minimum resolution of 0.1 °C (0.2 °F) and minimum accuracy of  $\pm 0.1$  °C ( $\pm 0.2$  °F).

6.2 *Vacuum Pump*, (when required to produce the vacuum), capable of reducing the pressure in the test chamber to less than 0.01 kPa (0.001 psia).

6.3 *Syringes*, (if required for sample introduction), gas-tight, 1 mL to 20 mL capacity with minimum accuracy and precision of  $\pm 1\%$ .

6.4 *Bath*, iced water or air, for chilling the samples and syringe (if required) to between 0 °C and 1 °C (32 °F to 34 °F).

6.5 *Pressure Measuring Device*, capable of measuring local station pressure with an accuracy of 0.20 kPa (0.03 psi) or better, at the same elevation relative to sea level as the apparatus in the laboratory.

6.5.1 When a mercury manometer is not used as the pressure measuring device, the calibration of the pressure measuring device employed shall be periodically checked (with traceability to a nationally recognized standard) to ensure that the device remains within the required accuracy specified in 6.5.

6.6 *McLeod Vacuum Gage or Calibrated Electronic Vacuum Measuring Device for Calibration*, to cover at least the range from 0.01 kPa to 0.67 kPa (0.1 mm Hg to 5 mm Hg). The calibration of the electronic vacuum measuring device shall be regularly verified in accordance with the annex section on Vacuum Sensors (A6.3) of Test Method D2892.

#### 7. Reagents and Materials

7.1 *Purity of Reagents*—Unless otherwise indicated, all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society<sup>4</sup> where such specifications are available. Lower purities can be used, provided it is first ascertained that the reagent is of sufficient purity to permit its use without lessening the accuracy of the determination. Reagents used for performance checks (see 10.3) shall be of at least 99 % purity.

<sup>4</sup> *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 *Annual 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.

7.2 *Propan-2-ol, Anhydrous*, (less than 0.1 % H<sub>2</sub>O). (**Warning**—Flammable.)

NOTE 5—It has been reported that, if not originally inhibited against it, propan-2-ol can contain peroxides. When this occurs, an explosion is possible when the storage of the vessel or other equipment such as a dispensing bottle, is near empty and approaching dryness.

7.3 *Toluene*, (**Warning**—Toluene is flammable and a health hazard.)

7.4 *n*-pentane, (**Warning**—Flammable, health hazard.)

## 8. Sampling

### 8.1 General:

8.1.1 Conduct bulk sampling to obtain the laboratory samples in accordance with Practice **D4057** except for gasoline-oxygenate blends where water displacement is not used. The extreme sensitivity of  $T_{(V/L)}$  measurements to losses through evaporation and the resulting changes in composition is such as to require the utmost precaution and the most meticulous care in the handling of samples. (**Warning**—Extremely flammable, harmful if inhaled or ingested. Skin irritant on repeated contact. Aspiration hazard.)

8.1.2 The size of the sample container from which the sample is taken shall be 1 L (1 qt). It shall be 70 % to 80 % filled with sample.

8.1.3 The precision statement will be derived using samples in 1 L (1 qt) containers. However, samples taken in containers of other sizes as prescribed in Practice **D4057** can be used if it is recognized that the precision could be affected. In the case of referee testing, the 1 L (1 qt) sample is mandatory.

8.1.4 Perform the  $T_{(V/L)}$  determination on the first test specimen withdrawn from the sample container. Do not use the remaining sample in the container for a second  $T_{(V/L)}$  determination. If a second determination is necessary, obtain a new sample.

8.1.5 Protect samples from excessive temperature prior to testing. This can be accomplished by storage in an appropriate ice bath or refrigerator.

8.1.6 Do not test samples stored in leaky containers. Discard and obtain a new sample if leaks are detected.

8.2 *Sampling Handling Temperature*—Cool the sample container and contents in an ice bath or refrigerator to between 0 °C and 1 °C (32 °F to 34 °F) the 0 °C to 1 °C (32 °F to 34 °F) range prior to opening the sample container. Ensure sufficient time to reach this temperature by direct measurement of the temperature of a similar liquid in a like container placed in the cooling bath at the same time as the sample temperature.

NOTE 6—One way to verify the sample temperature is by direct measurement of the temperature of a similar liquid in a similar container placed in the cooling bath or refrigerator at the same time as the sample. Alternatively, temperature-monitoring studies conducted by laboratories have determined the minimum amount of time necessary to achieve the required temperature requirements stated in 8.2, based upon typical sample receipt temperatures and cooling capacities of the instrumentation employed by the laboratory on samples included in such studies. The results of such studies have subsequently been applied to additional samples submitted for analysis. Typical minimum time durations reported by laboratories have ranged between approximately 30 min and 45 min, however, laboratories choosing this option need to determine the minimum cooling time required for their specific operation by conducting their own temperature-monitoring study.

### 8.3 Verification of Sample Container Filling:

8.3.1 With the sample at a temperature of 0 °C to 1 °C, take the container from the cooling bath or refrigerator and wipe dry with absorbent material. If the container is not transparent, unseal it and using a suitable gage, confirm that the sample volume equals 70 % to 80 % of the container capacity (see **Note 57**). If the sample is contained in a transparent glass container, verify that the container is 70 % to 80 % full by suitable means (see **Note 57**).

8.3.2 Discard the sample if the container is filled to less than 70 % by volume of the container capacity.

8.3.3 If the container is filled to more than 80 % by volume, pour out enough sample to bring the container contents to within the 70 % to 80 % by volume range. Do not return any sample to the container once it has been withdrawn.

NOTE 7—For non-transparent containers, one way to confirm that the sample volume equals 70 % to 80 % of the container capacity is to use a dipstick that has been pre-marked to indicate the 70 % and 80 % container capacities. The dipstick should be of such material that it shows wetting after being immersed and withdrawn from the sample. To confirm the sample volume, insert the dipstick into the sample container so that it touches the bottom of the container at a perpendicular angle, before removing the dipstick. For transparent containers, using a marked ruler or by comparing the sample container to a like container which has the 70 % and 80 % levels clearly marked, has been found suitable.

8.3.4 Reseal the container, if necessary, and return the sample container to the cooling bath or refrigerator.

### 8.4 Air Saturation of the Sample in the Sample Container:

8.4.1 *Transparent Container Only*—Since 8.3.1 does not require that the sample container be opened to verify the sample capacity, it is necessary to unseal the cap momentarily before resealing it, so that samples in transparent containers are treated the same as samples in non-transparent containers.

8.4.2 With the sample again at a temperature of 0 °C to 1 °C, take the container from the cooling bath or refrigerator, wipe it dry with an absorbent material, remove the cap momentarily, taking care that no water enters, reseal and shake vigorously. Return it to the bath or refrigerator for a minimum of 2 minutes.