



Designation: D6377 – 20

Standard Test Method for Determination of Vapor Pressure of Crude Oil: VPCR_x (Expansion Method)¹

This standard is issued under the fixed designation D6377; 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 This test method covers the use of automated vapor pressure instruments to determine the vapor pressure exerted in vacuum of crude oils. This test method is suitable for testing samples that exert a vapor pressure between 25 kPa and 180 kPa at 37.8 °C at vapor-liquid ratios from 4:1 and 0.02:1 ($X = 4$ and 0.02).

NOTE 1—This test method is suitable for the determination of the vapor pressure of crude oils at temperatures from 0 °C to 100 °C and pressures up to 500 kPa, but the precision and bias statements (see Section 14) may not be applicable. The current precision of the method is limited at vapor-liquid ratios of 0.02 and 4. (Section 14 is inclusive of vapor-liquid ratios of 0.02 and 4).

1.2 This test method also allows the determination of vapor pressure for crude oil samples having pour points above 15 °C provided the proper sample handling, transfer, and analysis procedures are followed.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this 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. For specific warning statements, see 7.2.1 – 7.3.2.*

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.*

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 D02.08 on Volatility.

Current edition approved June 1, 2020. Published June 2020. Originally approved in 1999. Last previous edition approved in 2016 as D6377 – 16. DOI: 10.1520/D6377-20.

2. Referenced Documents

2.1 ASTM Standards:²

- D323 Test Method for Vapor Pressure of Petroleum Products (Reid Method)
- D2892 Test Method for Distillation of Crude Petroleum (15-Theoretical Plate Column)
- D3700 Practice for Obtaining LPG Samples Using a Floating Piston Cylinder
- D4057 Practice for Manual Sampling of Petroleum and Petroleum Products
- D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products
- D5191 Test Method for Vapor Pressure of Petroleum Products and Liquid Fuels (Mini Method)
- D5842 Practice for Sampling and Handling of Fuels for Volatility Measurement
- D5853 Test Method for Pour Point of Crude Oils
- D6708 Practice for Statistical Assessment and Improvement of Expected Agreement Between Two Test Methods that Purport to Measure the Same Property of a Material
- D7975 Test Method for Determination of Vapor Pressure of Crude Oil: VPCR_x-F(T_m°C) (Manual Expansion Field Method)
- D8009 Practice for Manual Piston Cylinder Sampling for Volatile Crude Oils, Condensates, and Liquid Petroleum Products

3. Terminology

3.1 Definitions:

3.1.1 *platinum resistance thermometer*, n —temperature measuring device constructed with a length of platinum wire, whose electrical resistance changes in relation to temperature.

3.1.2 *vapor-liquid ratio (V/L)*, n —the ratio of the vapor volume to the liquid volume of specimen, in equilibrium, under specified conditions.

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.

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

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *dead crude oil, n*—crude oil with sufficiently low vapor pressure that, when exposed to normal atmospheric pressure at room temperature, does not result in boiling of the sample.

3.2.1.1 *Discussion*—Sampling and handling of dead crude oils can usually be done without loss of sample integrity or other problems by using normal, non-pressurized sample containers such as cans.

3.2.2 *live crude oil, n*—crude oil with sufficiently high vapor pressure that it would boil if exposed to normal atmospheric pressure at room temperature.

3.2.2.1 *Discussion*—Sampling and handling live crude oils requires a pressurized sample system and pressurized sample containers to ensure sample integrity and prevent loss of volatile components.

3.2.3 *Reid vapor pressure equivalent (RVPE), n*—a value calculated by a defined correlation equation (see Eq X1.1) from $VPCR_4$ at 37.8 °C that is expected to be equivalent to the vapor pressure value obtained by Test Method D323.

3.2.3.1 *Discussion*—As noted in 14.3 and Appendix X1, subsection X1.2, since Eq X1.1 for estimating RVPE is not universally applicable to all crude oils, it is recommended to report the $VPCR_4$ (37.8 °C) result for a crude oil sample.

3.2.4 *vapor pressure of crude oil ($VPCR_x$), n*—the pressure exerted in an evacuated chamber at a vapor-liquid ratio of X:1 by conditioned or unconditioned crude oil, which may contain gas, air or water, or a combination thereof, where X may vary from 4 to 0.02.

3.3 Abbreviations:

3.3.1 *ARV, n*—accepted reference value

3.3.2 *RVPE, n*—Reid vapor pressure equivalent

3.3.3 *V/L, n*—vapor liquid ratio

3.3.4 *$VPCR_x$, n*—vapor pressure of crude oil at x vapor liquid ratio

4. Summary of Test Method

4.1 Employing a measuring chamber with a built-in piston, a sample of known volume is drawn from the sample container into the temperature controlled chamber at 20 °C or higher. After sealing the chamber, the volume is expanded by moving the piston until the final volume produces the desired V/L value. The temperature of the measuring chamber is then regulated to the measuring temperature.

4.2 After temperature and pressure equilibrium, the measured pressure is recorded as the $VPCR_x$ of the sample. The test specimen shall be mixed during the measuring procedure by shaking the measuring chamber to achieve pressure equilibrium in a reasonable time of 5 min to 30 min.

4.3 For results related to Test Method D323, the final volume of the measuring chamber shall be five times the test specimen volume and the measuring temperature shall be 37.8 °C.

5. Significance and Use

5.1 Vapor pressure of crude oil at various V/Ls is an important physical property for shipping and storage.

NOTE 2—A vapor-liquid ratio of 0.02:1 ($X = 0.02$) mimics closely the situation of an oil tanker.

5.2 Vapor pressure of crude oil is important to crude oil producers and refiners for general handling and initial refinery treatment.

5.3 The vapor pressure determined by this test method at a vapor-liquid ratio of 4:1 ($VPCR_4$) of crude oil at 37.8 °C can be related to the vapor pressure value determined on the same material when tested by Test Method D323 (see Appendix X1).

5.4 Air saturation of crude oil shall not be done to avoid potential vapor loss. However air saturation of the chilled verification fluid is mandatory (see 7.2 and Section 11).

5.5 This test method can also be applied in online applications.

6. Apparatus

6.1 The apparatus suitable for this test method employs a small volume, cylindrically shaped measuring chamber with associated equipment to control the chamber temperature within the range from 0 °C to 100 °C. The measuring chamber shall contain a movable piston with a minimum dead volume of less than 1 % of the total volume at the lowest position to allow sample introduction into the measuring chamber and expansion to the desired V/L. A static pressure transducer shall be incorporated in the piston. The measuring chamber shall contain an inlet/outlet valve combination for sample introduction and expulsion. The piston and the valve combination shall be at the same temperature as the measuring chamber to avoid any condensation or excessive evaporation.

6.1.1 The measuring chamber shall be designed to have a total volume of 5 mL to 15 mL and shall be capable of maintaining a V/L of 4:1 to 0.02:1. The accuracy of the adjusted V/L shall be within 0.01.

NOTE 3—The measuring chambers employed by the instruments used in generating the precision and bias statements were constructed of nickel plated aluminium, stainless steel and brass with a total volume of 5 mL. Measuring chambers exceeding a 5 mL capacity and different design can be used, but the precision and bias statement (see Section 14) may not be applicable.

6.1.2 The pressure transducer shall have a minimum operational range from 0 kPa to 500 kPa with a minimum resolution of 0.1 kPa and a minimum accuracy of ± 0.5 kPa. The pressure measurement system shall include associated electronics and readout devices to display the resulting pressure reading.

6.1.3 Electronic temperature control shall be used to maintain the measuring chamber at the prescribed temperature within ± 0.1 °C for the duration of the test.

6.1.4 A platinum resistance thermometer shall be used for measuring the temperature of the measuring chamber. The minimum temperature range of the measuring device shall be from 0 °C to 100 °C with a resolution of 0.1 °C and an accuracy of ± 0.1 °C.

6.1.5 The vapor pressure apparatus shall have provisions for rinsing the measuring chamber with the next sample to be tested or with a solvent of low vapor pressure.

6.1.6 The vapor pressure apparatus shall have provisions for shaking the sample during the measuring procedure with a minimum frequency of 1.5 cycles per second.