



**Designation: D3427 – 19**



**Designation 313–01**

## **Standard Test Method for Air Release Properties of Hydrocarbon Based Oils<sup>1</sup>**

This standard is issued under the fixed designation D3427; 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 ability of turbine, hydraulic, and gear oils to separate entrained air.

NOTE 1—This test method was developed for hydrocarbon based oils. It may be used for some synthetic fluids; however, the precision statement applies only to hydrocarbon based oils.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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.*

1.4 *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:*<sup>2</sup>

D1193 Specification for Reagent Water

D1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

<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.C0.02 on Corrosion and Water/Air Separability.

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This standard has been developed through the cooperative effort between ASTM International and the Energy Institute, London. The EI and ASTM International logos imply that the ASTM International and EI standards are technically equivalent, but does not imply that both standards are editorially identical. Adopted as a joint ASTM/IP standard in 2006.

<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.

E1 Specification for ASTM Liquid-in-Glass Thermometers

2.2 DIN Standard:<sup>3</sup>

DIN 51 381

### **3. Terminology**

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *air release time, n*—the number of minutes needed for air entrained in the oil to reduce in volume to 0.2 % under the conditions of this test and at the specified temperature.

### **4. Summary of Test Method**

4.1 Compressed air is blown through the test oil, which has been heated to a temperature of 25 °C, 50 °C, or 75 °C. After the air flow is stopped, the time required for the air entrained in the oil to reduce in volume to 0.2 % is recorded as the air release time.

NOTE 2—By agreement between the customer and the laboratory, the oil may be heated at other temperatures. However, the precision at these different temperatures is not known at present.

### **5. Significance and Use**

5.1 Agitation of lubricating oil with air in equipment, such as bearings, couplings, gears, pumps, and oil return lines, may produce a dispersion of finely divided air bubbles in the oil. If the residence time in the reservoir is too short to allow the air bubbles to rise to the oil surface, a mixture of air and oil will circulate through the lubricating oil system. This may result in an inability to maintain oil pressure (particularly with centrifugal pumps), incomplete oil films in bearings and gears, and poor hydraulic system performance or failure.

5.2 This test method measures the time for the entrained air content to fall to the relatively low value of 0.2 % volume under a standardized set of test conditions and hence permits the comparison of the ability of oils to separate entrained air under conditions where a separation time is available. The significance of this test method has not been fully established. However, entrained air can cause sponginess and lack of sensitivity of the control of turbine and hydraulic systems. This

<sup>3</sup> Available from Beuth Verlag GmbH, Burggrafenstrasse 6, 1000 Berlin 30, Germany.

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

test may not be suitable for ranking oils in applications where residence times are short and gas contents are high.

## 6. Apparatus

6.1 A schematic diagram of the apparatus is shown in Fig. 1. The component parts are described as follows:

6.1.1 *Test Vessel*, made of borosilicate glass as shown in Fig. 2, consisting of a jacketed sample tube fitted with an air inlet capillary, baffle plate, and air outlet tube. The two parts of each test vessel should be marked and preferably used as a pair. Interchanged parts may be used so long as the resultant test vessel conforms to the stated dimensions.

NOTE 3—Users are advised to verify the distance between the air inlet capillary and the bottom of the test cell as described in the method, by using an appropriate measuring device. It has been noted by some laboratories that variation from the required measurements has significant effect on results.

6.1.2 *Pressure Gage*, covering the range from 0 kPa to 35 kPa, with divisions at least every 2 kPa, and an accuracy of 1.5 kPa.

### 6.1.3 Thermometers.

6.1.3.1 *Air Thermometer*, for measuring compressed air temperature. ASTM Precision Thermometer having a range from  $-20^{\circ}\text{C}$  to  $102^{\circ}\text{C}$ , graduated in  $0.2^{\circ}\text{C}$  and conforming to the requirements for Thermometer 12C as prescribed in Specification E1 is suitable. A temperature sensor of at least equivalent performance is also suitable. Care shall be taken to avoid restricting the air path with the thermometer bulb or any adapter used.

6.1.3.2 *Sample Thermometer*, for measuring the temperature of the sample during preparation and trial runs. ASTM Precision Thermometer having a range from  $-20^{\circ}\text{C}$  to  $102^{\circ}\text{C}$ , graduated in  $0.2^{\circ}\text{C}$  and conforming to the requirements for Thermometer 12C as prescribed in Specification E1 is suitable. A temperature sensor of at least equivalent performance is also suitable.

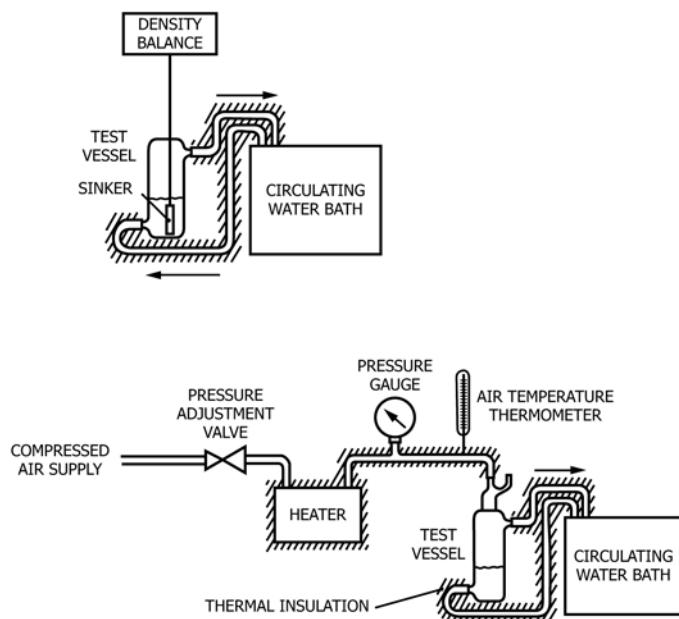


FIG. 1 Apparatus for the Determination of Air Release Time

6.1.4 *Heater*, to bring the compressed air up to measurement temperature. A coil of copper tubing immersed in the circulating bath (see 6.1.5) is suitable at  $25^{\circ}\text{C}$ , but additional heating is necessary at  $50^{\circ}\text{C}$  and  $75^{\circ}\text{C}$ . This can be obtained by an additional bath, or by using a separate steam or electric heat exchanger. The temperature of the air shall be measured by a thermometer located as close as possible to the testing vessel and meeting the specifications shown in 6.1.3.

NOTE 4—The application of thermal insulation to the pipework carrying the heated compressed air is recommended.

6.1.5 *Circulating Bath*, approximately 10 L capacity with a rate of flow of 10 L/min and capable of maintaining the test cell at a temperature of  $25^{\circ}\text{C}$ ,  $50^{\circ}\text{C}$ , or  $75^{\circ}\text{C}$  within  $\pm 0.1^{\circ}\text{C}$ .

NOTE 5—Use of water in the bath has been found to minimize electrostatic effects.

NOTE 6—The application of thermal insulation to the pipework carrying the heated bath fluid is recommended.

**(Warning)**—The use of glass vessels with glass hose fittings for circulating  $75^{\circ}\text{C}$  bath medium is potentially dangerous. Back pressure in excess of a gage pressure of 70 kPa can be generated when the bath medium is pumped at the required rate; this can cause fracture of the glass or slippage of the hose connections. Use of a pressure relief valve set at 70 kPa is recommended. In addition, use of a safety shield is recommended.)

6.2 *Balance*, capable of measuring density, accurate to  $0.5 \text{ kg/m}^3$ .

6.3 *Sinker*, having a round or tapered bottom of 5 mL or 10 mL displacement,  $80.0 \text{ mm} \pm 1.5 \text{ mm}$  length. If the sinker contains a thermometer, it shall be usable between  $25^{\circ}\text{C}$  and  $75^{\circ}\text{C}$ .

6.4 *Oven*, capable of heating samples to  $10^{\circ}\text{C}$  above the test temperature.

6.5 *Timer*, readable to 1 s, with an accuracy of better than 0.1 %.

6.6 *Pump*, with a nonpulsating output and capable of maintaining an air flow of 40 L/min at a pressure of 20 kPa (optional, see 7.4).

## 7. Materials

7.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society where such specifications are available.<sup>4</sup> Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

7.2 *Purity of Water*—Reagent water as defined by Type II of Specification D1193.

<sup>4</sup> ACS Reagent Chemicals, Specifications and Procedures for Reagents and Standard-Grade Reference Materials, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see Analar 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.

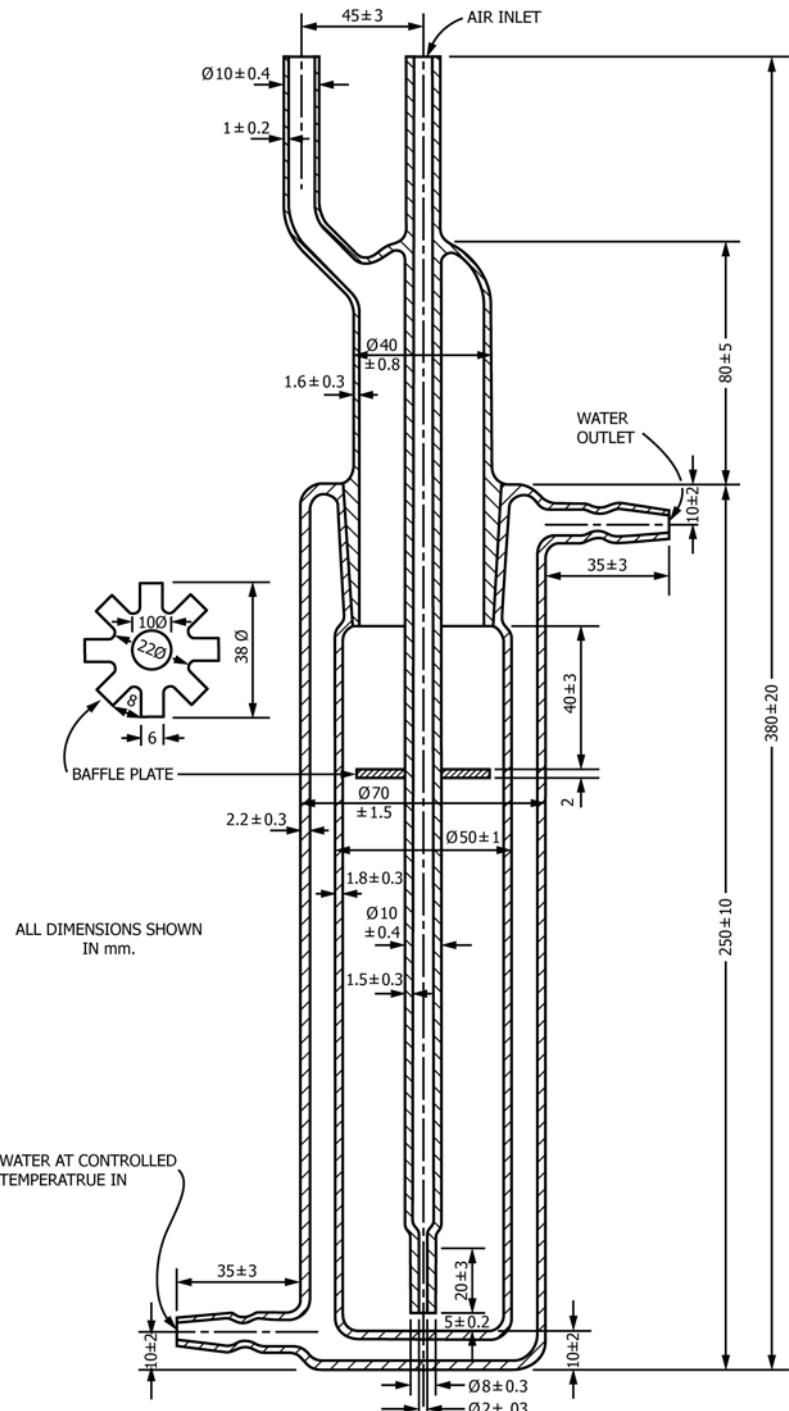


FIG. 2 Test Vessel

7.3 Acetone, minimum reagent grade. (**Warning—**  
Flammable. Health hazard.)

7.4 *Air; Compressed*, dry and free from moisture, particulates, and oil. Air from a cylinder or a nonpulsating pump may be used. (**Warning**—Compressed gas under high pressure.)

7.5 *Cleaning Reagent*, Cleaning either in hot Nochromix<sup>5</sup> (**Warning**—Corrosive health hazard oxidizer), or a 24 h soak at room temperature in Micro<sup>6</sup> solution.

NOTE 7—Previously, chrome sulfuric acid was used in this procedure. Other test methods (for example, Test Method D1401) have demonstrated acceptable, statistically equivalent results when Nochromix or Micro is used to replace sulfuric chromic acid for cleaning.

7.6 *n-Heptane*, reagent grade. (**Warning**—Flammable. Harmful if inhaled.)

NOTE 8—Other alternate solvents, such as toluene, etc., may be used in place of *n*-heptane.

## 8. Sampling

8.1 Sample in accordance with the instructions described in Practice D4057.

## 9. Preparation of Apparatus

9.1 Clean the interior of the test vessel, including the air inlet and sinker, and all other glassware coming in contact with the sample, before each determination in the following manner:

9.1.1 Rinse away the oil residue with *n*-heptane (**Warning**—see 7.6) and acetone (**Warning**—see 7.3) and dry by air blowing.

9.1.2 Clean the apparatus by immersing in cleaning reagent in order to remove completely any traces of silicone.

9.1.3 Rinse with reagent water.

9.1.4 Rinse with acetone (**Warning**—see 7.3) and dry with clean compressed air (**Warning**—see 7.4).

NOTE 9—Oil misting occurs during blowing. The test vessel should be in a hood, or the air outlet tube should be connected to a vent that removes the vapors.

## 10. Procedure

10.1 Assemble the test apparatus as shown in Fig. 1. Set the compressed air temperature to within 0.2 °C of the desired test temperature. Set the circulating bath to give a specimen temperature within 0.1 °C of the desired test temperature. The required bath temperature setting and time for the specimen to equilibrate can be established for an equipment setup by making trial runs with a thermometer in the oil specimen. For oils with a viscosity at 40 °C of less than 9.0 mm<sup>2</sup>/s, the test temperature shall be 25 °C. For oils with a viscosity at 40 °C between 9.0 mm<sup>2</sup>/s and 90 mm<sup>2</sup>/s, the test temperature shall be

50 °C. Oils having a viscosity at 40 °C greater than 90 mm<sup>2</sup>/s shall be tested at 75 °C.

10.2 Warm approximately 200 mL of the oil to be tested in an oven set at a temperature of 10 °C higher than the test temperature. Allow the sample to reach the test temperature. This may take about 20 min.

10.3 Pour 180 mL ± 5 mL of the heated sample into the test vessel.

10.4 Allow the sample to equilibrate to the desired test temperature, using the heating-up time previously established (see 10.1) or by directly measuring the temperature.

10.5 Warm the sinker of the balance to the test temperature in an air bath, such as a glass cylinder fitted with a suitable cover situated in the circulating bath. When the sinker has reached the test temperature, immerse it in the sample, taking care that no air bubbles cling to it. Attach the sinker to the beam of the density balance by means of the platinum wire so that the bottom of the sinker is 10 mm ± 2 mm from the bottom of the test vessel.

NOTE 10—The sinker can take approximately 20 min to reach 50 °C or 35 min to reach 75 °C.

10.6 Allow the density reading to stabilize, read the density from the balance to the nearest 0.1 kg/m<sup>3</sup>, and record it as the initial density.

10.7 Return the sinker to the air bath and replace it with the air inlet tube as shown in Fig. 2. After 5 min, start the supply of air at a gage pressure of 20 kPa at the required temperature. Maintain the pressure and temperature of the air 25 °C, 50 °C, or 75 °C by readjustments, if necessary.

10.8 After 7 min ± 0.1 min, shut off the air and immediately start the timer. Quickly remove the inlet tube from the test vessel, and immerse the sinker in the oil/air dispersion. Attach the wire to the beam and maintain a distance of 10 mm ± 2 mm between the bottom of the sinker and the bottom of the test vessel.

NOTE 11—In the case of certain oils, which form a considerable volume of oil/air dispersion, the top of the sinker can initially be in foam, and hence, density readings at this time can be in error.

10.9 Record the time, to the nearest 0.1 min (6 s), for the density to return to the target of 99.8 % of the initial density (d<sub>0</sub>). If the time is greater than 30 min, discontinue the test.

NOTE 12—The test may be run for a longer period of time by agreement between the laboratory and the customer.

NOTE 13—For some applications, the shape of the air release time curve may be required. This can be implemented by recording the density at intervals, as required.

10.10 Certain oils may lose light components during the air saturation, thus changing their effective density. This will be noted if the time for the density to return to the initial figure is instantaneous. Where air release value information is required for such oils, an air releasing time curve may be drawn. If the loss causes any part of the sinker to be exposed, discontinue the test and repeat, using a sample that is 10 mL larger than previously used.

<sup>5</sup> The sole source of supply of Nochromix known to the committee at this time is Godax Laboratories, Inc., 720-B Erie Ave., Takoma Park, MD 20912. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

<sup>6</sup> The sole source of supply of Micro known to the committee at this time is International Products Corp., P.O. Box 70, Burlington, NJ 08016. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,<sup>1</sup> which you may attend.

## 11. Calculation of Density

### 11.1 Density:

$$\text{Density of sample (kg/m}^3\text{)} = \frac{[\text{Mass of sinker in air (kg)} - \text{Mass of sinker in sample (kg)}]}{\text{Volume of sinker (m}^3\text{)}} \quad (1)$$

Density of sample (kg/m<sup>3</sup>) =

NOTE 14—A 10 mL sinker has a volume of  $10 \text{ m}^3 \times 10^{-6} \text{ m}^3$ .

### 11.2 Target Density:

$$\text{Initial density (d}_0\text{)} \times 0.998. \quad (2)$$

11.3 If the tare key of the balance is pressed while the sinker is being weighed in air so that the reading is zeroed, then the following may be used:

$$\text{Density of sample (kg/m}^3\text{)} = \frac{\text{Mass of sinker in sample (kg)}}{\text{Volume of sinker (m}^3\text{)}} \quad (3)$$

NOTE 15—Some instruments automatically make the above calculations.

11.4 The volume of the sinker may be determined by weighing it in air, then in water. The difference in mass (kg)  $\times 10^{-3}$  = volume in m<sup>3</sup>.

## 12. Reporting

12.1 Report the air release time, as recorded in 10.9, and the test temperature in degrees Celcius.

## 13. Precision and Bias<sup>7</sup>

NOTE 16—The program was run by sixteen laboratories, using eighteen samples of unused and in-service turbine, hydraulic, and gear oils. Six samples were tested in blind replicate at each test temperature (25 °C, 50 °C, and 75 °C). Since some reports were incomplete or found to be outliers, this resulted in 243 data points for the final statistical analysis.

13.1 *Precision*—The precision of this test method as determined by statistical examination of interlaboratory results is as follows:

NOTE 17—The precision statement was developed using hot Nucharomix<sup>5</sup> or Micro<sup>6</sup> solutions described in the cleaning reagent section of the test procedure.

<sup>7</sup> Supporting data (the results of the cooperative test program, from which these values have been derived) have been filed at ASTM International Headquarters and a copy may be obtained by requesting Research Report RR:D02-1915. Contact ASTM Customer Service at service@astm.org.

13.1.1 *Repeatability*—The difference between two test results, obtained by the same operator with the same apparatus under constant operating conditions on identical test material, would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

$$r = 0.5799 * \bar{X}^{0.85} \text{ minutes} \quad (4)$$

where:

$\bar{X}$  = average of two results being compared.

13.1.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working in different laboratories on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in twenty:

$$R = 0.8206 * \bar{X}^{0.85} \text{ minutes} \quad (5)$$

where:

$\bar{X}$  = average of two results being compared.

13.2 The closely related test method DIN 51 381 reports precision in another format. For ready comparison, the above statement is shown in DIN terms in Table 1.

13.3 *Bias*—The procedure in Test Method D3427 for measuring air release properties of petroleum oils has no bias because the value of the air bubble separation time is defined only in terms of this test method. There is no known bias relative to the DIN 51 381 method.

## 14. Keywords

14.1 air entrainment; air release time; gear oil; hydraulic oil; turbine oil

**TABLE 1 Comparison of ASTM and DIN Precision Data**

Mean Test Result, min	Repeatability		Reproducibility	
	DIN	ASTM	DIN	ASTM
Up to 5	1	0.7	2	2.1
Over 5 to 10	2	1.3	3	3.6
Over 10 to 15	3	1.6	4	4.7

## SUMMARY OF CHANGES

Subcommittee D02.C0 has identified the location of selected changes to this standard since the last issue (D3427 – 15) that may impact the use of this standard. (Approved Dec. 1, 2019.)

- (1) Revised Section 13 Precision and Bias Note 16.
- (2) Revised subsection 13.1 Statement on Precision Note 17.
- (3) Revised subsection 13.1.1 Repeatability.

- (4) Revised subsection 13.1.2 Reproducibility.
- (5) Deleted 13.3 Bias Note 18.
- (6) Revised Section 13 Footnote 7.

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