



# Standard Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration<sup>1</sup>

This standard is issued under the fixed designation D 3339; 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 acidic constituents in new or used petroleum products and lubricants soluble or nearly soluble in mixtures of toluene, and isopropyl alcohol. The test method is especially intended for cases in which the amount of sample available to be analyzed is too small to allow accurate analysis by Test Methods D 974 or D 664. It is applicable for the determination of acids having dissociation constants in water larger than  $10^{-9}$ . Extremely weak acids having dissociation constants smaller than  $10^{-9}$  do not interfere. Salts titrate if their hydrolysis constants are larger than  $10^{-9}$ .

1.2 This test method can be used to indicate relative changes in acid number that occur in an oil during use under oxidizing conditions. Although the titration is made under definite equilibrium conditions, the method does not measure an absolute acidic property that can be used to predict performance of an oil under service conditions. No general relationship between bearing corrosion and acid number is known.

1.3 Since this test method requires substantially less sample than Test Methods D 974 or D 664, it provides an advantageous means of monitoring an oxidation test by changes in acid number by (1) minimizing test sample depletion for acid number analyses and thus minimizing the disturbance of the test or (2) allowing additional acid number analyses to be made while maintaining the same test sample depletion and thus providing additional data.

NOTE 1—Some oils, such as many cutting oils, rust-proofing oils, and similar compounded oils, or excessively dark-colored oils, may be more difficult to analyze by this test method due to obscurity of the color-indicator end point. These oils can be analyzed by Test Method D 664 provided sufficient sample is available. However, this situation is much less likely using Test Method D 3339 than using Test Method D 974 due to the use of a more highly dilute sample during the titration and due to the greater stability of the end point color change. The acid numbers

obtained by Test Method D 3339 may or may not be numerically the same as those obtained by Test Method D 664 but they should be of the same order of magnitude.

NOTE 2—The results obtained using this method have been found to be numerically the same as those obtained using Test Method D 974, within the precision of the two methods, for new or oxidized lubricants of the type primarily intended for hydraulic or steam turbine type service. The oxidized lubricants were obtained using the Test Method D 943 oxidation test. This correlation is shown by the correlation coefficient  $r = 0.989$  with slope  $s = +1.017$  and intercept  $y = +0.029$ , calculated using the acid numbers obtained using both titration methods for the samples used for the precision statement (12.2).<sup>2</sup>

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *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 warning statements, see Sections 7 and 9, A1.1.4, A2.3.1, and A2.10.1.

## 2. Referenced Documents

### 2.1 ASTM Standards:<sup>3</sup>

- D 664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration
- D 943 Test Method for Oxidation Characteristics of Inhibited Mineral Oils
- D 974 Test Method for Acid and Base Number by Color-Indicator Titration
- D 1193 Specification for Reagent Water

## 3. Terminology

### 3.1 Definitions:

<sup>2</sup> Use of the correlation coefficient is given in Mack, C., *Essentials of Statistics for Scientists and Technologists*, Plenum Press, New York, NY, 1967, or other publications on statistics.

<sup>3</sup> 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.

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.06 on Analysis of Lubricants.

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

3.1.1 *acid number, n*—the quantity of base, expressed in milligrams of potassium hydroxide per gram of sample, that is required to titrate a sample dissolved in a specified solvent to a specified end point.

3.1.1.1 *Discussion*—In this test method, acids or salts with dissociation constants greater than  $10^{-9}$ , are titrated to a green end point with *p*-naphtholbenzein indicator.

3.1.2 *used oil, n*—any oil that has been in a piece of equipment (for example, an engine, gearbox, transformer or turbine) whether operated or not.

3.1.2.1 *Discussion*—Typically, in this test method, the acidity of oxidized hydraulic or steam turbine oils is measured.

## 4. Summary of Test Method

4.1 To determine the acid number a sample of the oil is dissolved in a solvent consisting of toluene, isopropyl alcohol, and a small amount of water. The resulting single-phase solution is titrated at room temperature under a nitrogen atmosphere with standardized 0.01 *M* potassium hydroxide (KOH) in isopropyl alcohol to the stable green color of the added *p*-naphtholbenzein indicator.

## 5. Significance and Use

5.1 This test method measures the acid number of oils obtained from laboratory oxidation tests using smaller amounts of sample than Test Methods **D 974** or **D 664**. It has specific application in Test Method **D 943** in which small aliquots of oil are periodically removed for testing by Test Method **D 3339**. This test method, therefore, provides a means of monitoring the relative oxidation of oils, by measuring changes in acid number, at different time intervals and under the various oxidizing test conditions.

## 6. Apparatus (Refer to **Fig. 1**)

6.1 *Titration Buret*—A micro scale, automatic buret with 0.01 mL subdivisions and at least a 2-mL buret capacity.

6.2 *Titrant Reservoir*—The preferred reservoir is one that is integral with the automatic buret, such as shown in **Fig. 1**. A titrant reservoir separate from the automatic buret may be used if the line connecting the reservoir with the buret is all glass. Exposure of the titrant to light should be minimized by use of amber glass for the reservoir, by wrapping the reservoir with foil such as aluminum foil, or by other suitable means. Also, the tube in the reservoir for titrant withdrawal is adjusted so that the end of the tube is about 20 mm (0.8 in.) from the bottom of the reservoir so that any precipitate that may collect on the bottom of the reservoir will not be disturbed. To further avoid disturbing any precipitate in the reservoir, movement of the reservoir must be minimized.

6.2.1 With either type of reservoir all entrances and exits to the buret and reservoir must be connected to absorption tubes to remove atmospheric carbon dioxide and water, for example, tubes containing 10 to 20-mesh anhydrous calcium sulfate as desiccant and soda-lime as carbon dioxide absorbent. Precautions must be taken to prevent introduction of any soda-lime into the titrant reservoir or buret.

6.3 *Titration Beaker*—100-mL capacity tall-form Berzelius beaker without pouring spout. Approximate dimensions are 47 mm in inside diameter and 79 mm in height.

6.4 *Titration Beaker Purging Stopper*—A stopper to enclose the titration beaker. The stopper must be composed of an elastomeric material, such as neoprene, that is essentially unaffected by the titration solvent. Approximate stopper dimensions are 53 mm top diameter, 45 mm bottom diameter, and 25 mm height. The stopper is fitted with a 8-mm (0.3-in.) outside diameter glass inlet tube extending  $15 \pm 2$  mm beyond the bottom of the stopper and with a  $7 \pm 1$ -mm inside diameter hole. The inlet tube and hole are placed on opposite sides of the stopper with a center-to-center separation distance of  $30 \pm 1$  mm.

6.5 *Purge Gas Rotameter*, capable of indicating a flow rate of 10 L/h.

6.6 *Stirrer Motor*, variable speed, magnetically linked.

NOTE 3—A propeller may also be used instead of a magnetic stirrer to mix the samples.

6.7 *Stirring Bar*, cylindrical, TFE-fluorocarbon encased, 25.4 mm long and 7.9 mm in diameter.

6.8 *Pipet*, capable of transferring  $0.100 \pm 0.002$  mL of titration indicator solution.

6.9 *Titration Solvent Buret*—A 500-mL or larger capacity buret with 5-mL subdivisions. The top of the buret is stoppered and connected with an absorption tube, as in **6.2**, to remove atmospheric carbon dioxide and water. An alternative means of dispensing the titration solvent may be used provided a dispensing repeatability within  $\pm 1$  mL for 40 mL is obtainable and the solvent in the dispenser is isolated from atmospheric carbon dioxide and water.

NOTE 4—An automated photometric device may also be used for detecting the titration end point. However, the precision estimates given in Section **13** may not apply to this mode of titration.

## 7. Reagents and Materials

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

7.2 *Purity of Water*—All references to water shall be understood to mean freshly distilled (carbon dioxide-free) water conforming to Specification **D 1193**, Type II or III.

7.3 *Ethyl Alcohol*—(**Warning**—Flammable. Denatured—Cannot be made nontoxic.) USP 200 proof or denatured alcohol according to Formula 30 of the U. S. Bureau of Internal Revenue.

7.4 *Propanol-2-ol, (Isopropyl Alcohol) Anhydrous*, (**Warning**—Flammable, see also **Note 5**.) containing less than 0.9 % water.

<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 *Anal. 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.

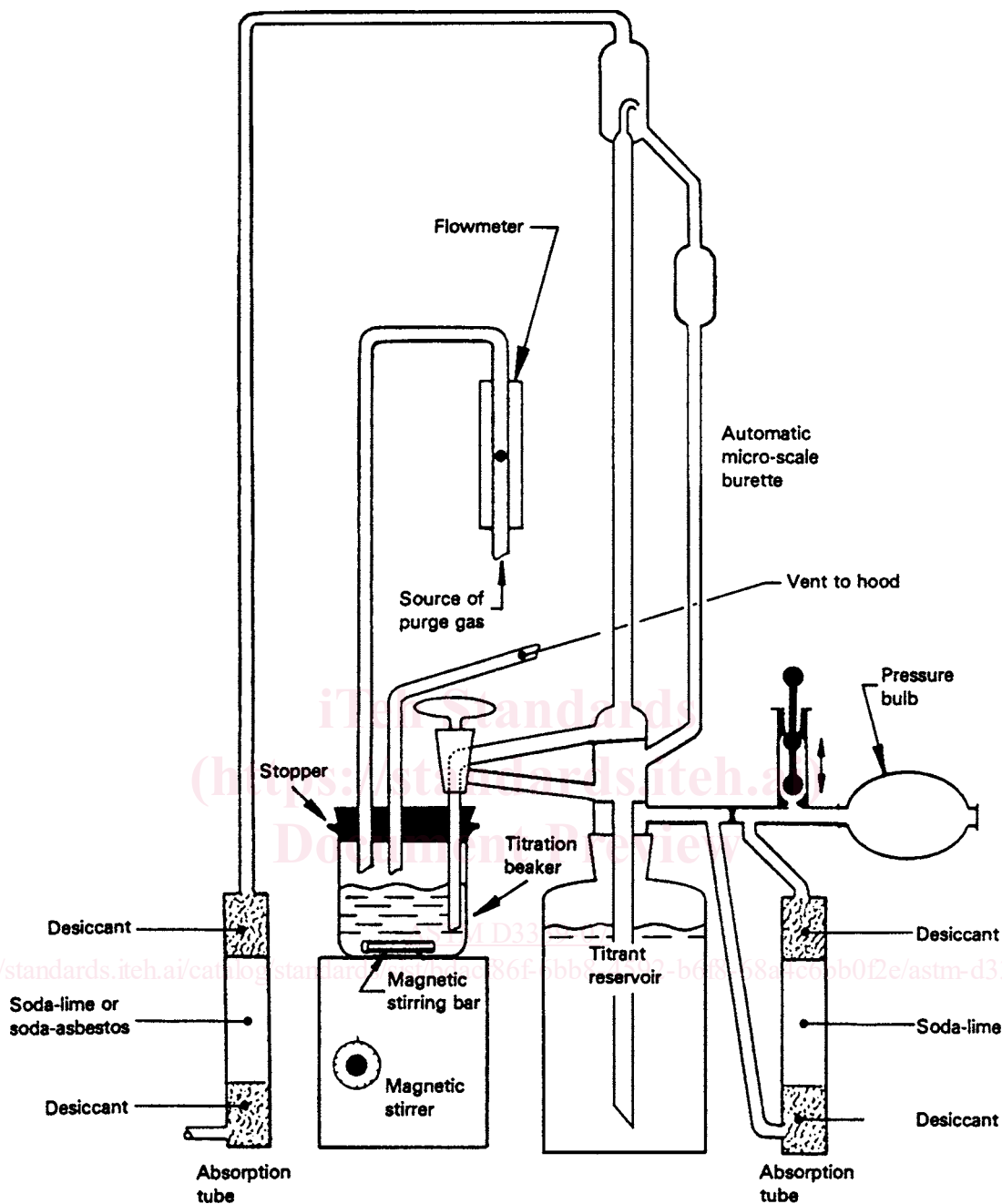


FIG. 1 Schematic Drawing of Typical Apparatus

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

7.5 *p*-Naphtholbenzein Indicator<sup>5,6</sup> Solution—The *p*-naphtholbenzein must meet the specifications given in Annex

A1. Prepare a solution containing 10 g of *p*-naphtholbenzein per litre of titration solvent.

7.6 Nitrogen, dry and carbon dioxide-free.

7.6.1 In order to obtain repeatable results and a stable end point color change, it is especially important that the nitrogen purge gas be free of carbon dioxide. Prepurified grade nitrogen has been found to be satisfactory.

<sup>5</sup> In a 2006 study, only Kodak, Baker (Mallinkrodt), Fluka, and Aldrich were found to meet the specifications in Annex A1. However, Kodak brand is no longer available.

<sup>6</sup> Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: D02-1626.

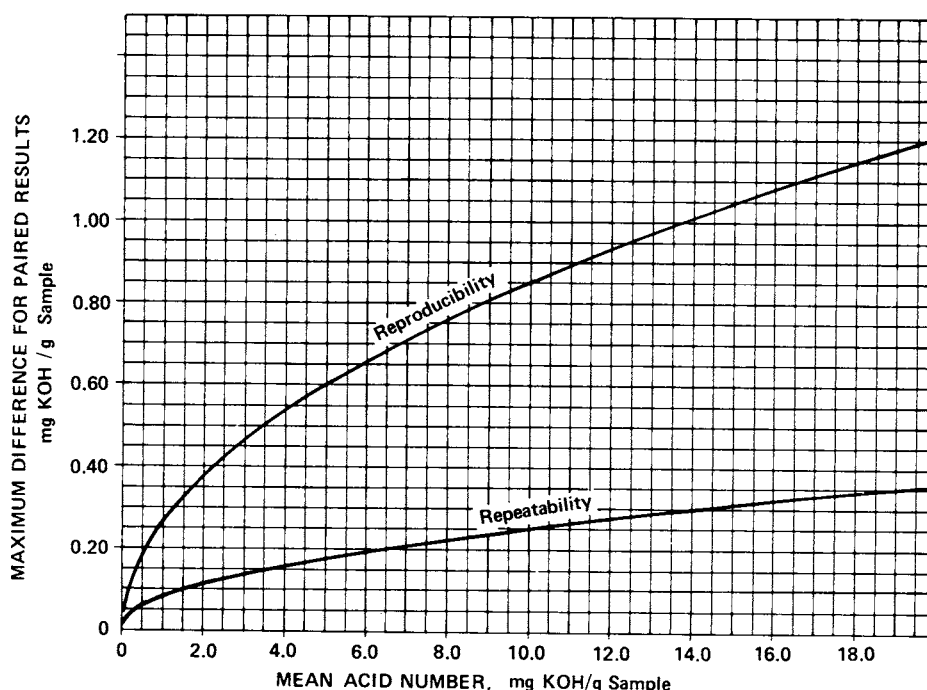


FIG. 2 Precision Curves

7.7 *Phenolphthalein Indicator Solution*—Dissolve 0.10 g of solid pure phenolphthalein in 50 mL of water and 50 mL of ethyl alcohol.

7.8 *Titration Solvent*—Consisting of  $5.0 \pm 0.1$  mL of water,  $495 \pm 1$  mL of anhydrous propanol-2-ol, and  $500 \pm 1$  mL of toluene.

7.9 *Potassium Hydroxide Solution, Standard Alcoholic (0.01 M)* (**Warning**—Corrosive.).

NOTE 6—Commercially available reagents may be used in place of laboratory preparations.

7.9.1 *Preparation*—Add 3 g of solid KOH to approximately 1 L of anhydrous propanol-2-ol (isopropyl alcohol) (containing less than 0.9 % water) in a 2-L Erlenmeyer flask. Boil the mixture gently on a steam bath for 10 to 15 min while stirring to prevent caking of solids on the bottom of the flask. Add about 1 g of barium hydroxide and again boil gently for about 10 min. Cool to room temperature, stopper to prevent contact with the room atmosphere and allow to stand overnight (about 16 h). Filter the supernatant liquid through a 10- $\mu$ m TFE-fluorocarbon membrane filter while avoiding unnecessary exposure to the atmosphere and then dilute the solution (approximately 0.05 M) with anhydrous isopropyl alcohol to a total volume of about 5 L (Note 7). Store the titrant in a chemically resistant dispensing bottle out of contact with cork, rubber, or saponifiable stopcock lubricant and protected by a guard tube containing soda-lime. Minimize exposure of the titrant to light by storing in the dark or in an amber bottle or by wrapping the bottle with aluminum foil.

NOTE 7—Care should be taken to ensure a final normality of  $0.011 \pm 0.002$ .

NOTE 8—Because of the relatively large coefficient of cubic expansion of organic liquids, such as propanol-2-ol, the standard alcoholic solutions should be standardized at temperatures close to those employed in the titrations of samples.

7.9.2 *Standardization*—The titrant is standardized (Note 8) against dried (at least 1 h at  $110^\circ\text{C}$ ), pure potassium hydrogen phthalate using the method described in 9.1 for the acid number analysis, with the exception that water ( $40 \pm 1$  mL) is used as the solvent and 6 drops of phenolphthalein solution is used as the indicator. The blank is obtained in the same manner except that the potassium hydrogen phthalate is excluded. Standardize the titrant frequently enough to detect changes of 0.0003 M. The mean molarity determined by at least duplicate analyses is used as the titrant molarity for the acid number calculations.

7.10 *Toluene* (**Warning**—Flammable. Vapor harmful.) Nitration-grade, or equivalent.

## 8. Preparation of Used Oil Samples

8.1 Strict observance of the sampling procedure described in 8.2 is necessary, since the sediment itself is acidic or basic or has adsorbed acidic or basic material from the sample. Failure to obtain a representative sample causes serious errors.

8.2 Heat the sample (Note 9) of used oil to  $60 \pm 5^\circ\text{C}$  in the original container and agitate until all sediment is homogeneously suspended in the oil (Note 10). If the original container is of opaque material, or if it is more than three fourths full, transfer the entire sample to a clear glass bottle having a capacity at least one third greater than the volume of the sample. Transfer all traces of sediment from the original container to the bottle by violent agitation of portions of the sample in the original container. After complete suspension of all sediment, strain the sample or a convenient aliquot of the sample through a 100-mesh screen for the removal of large contaminating particles (Note 11).

NOTE 9—When samples are visibly free of sediment, the heating procedure may be omitted.

NOTE 10—As used oil can change appreciably in storage, samples