



Designation: D6074 – 15 (Reapproved 2022)

## Standard Guide for Characterizing Hydrocarbon Lubricant Base Oils<sup>1</sup>

This standard is issued under the fixed designation D6074; 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 guide suggests physical, chemical, and toxicological test methods for characterizing hydrocarbon lubricant base oils derived from various refining processes including re-refining used oils and refining crude oil. This guide does not contain limits nor does it purport to cover all tests which could be employed; rather, it represents the first step in better describing important parameters of lubricant base oils affecting lubricant performance and safe handling. Tests have been identified to characterize the composition and performance of base oils in addition to verifying their consistency. Undesirable components have also been identified with a range of typical levels. These are not limits. It is the responsibility of the buyer and seller to determine and agree upon the implementation of this guide.

1.2 This guide applies only to base oils and not to finished lubricants.

1.3 Base oils containing detectable levels of esters, animal fats, vegetable oils, or other materials used as, or blended into, lubricants are not covered by this guide.

1.4 This guide is relevant to base oils composed of hydrocarbons and intended for use in formulating products including automotive and industrial lubricants. Although not intended to cover all base oil viscosity grades, this guide does cover the majority of viscosities that would be used in both automotive and industrial oil formulations. These base oils would typically have a viscosity of approximately 2 mm<sup>2</sup>/s to 40 mm<sup>2</sup>/s (cSt) at 100 °C (50 SUS to 3740 SUS at 100 °F).

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

1.6 *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.*

<sup>1</sup> This guide is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.P0 on Recycled Products.

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1.7 *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>

- D91 Test Method for Precipitation Number of Lubricating Oils
- D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester
- D93 Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
- D97 Test Method for Pour Point of Petroleum Products
- D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
- D189 Test Method for Conradson Carbon Residue of Petroleum Products
- D287 Test Method for API Gravity of Crude Petroleum and Petroleum Products (Hydrometer Method)
- D341 Practice for Viscosity-Temperature Equations and Charts for Liquid Petroleum or Hydrocarbon Products
- D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
- D524 Test Method for Ramsbottom Carbon Residue of Petroleum Products
- D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration
- D974 Test Method for Acid and Base Number by Color-Indicator Titration
- D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
- D1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
- D1500 Test Method for ASTM Color of Petroleum Products

<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.

- (ASTM Color Scale)
- D2007** Test Method for Characteristic Groups in Rubber Extender and Processing Oils and Other Petroleum-Derived Oils by the Clay-Gel Absorption Chromatographic Method
- D2161** Practice for Conversion of Kinematic Viscosity to Saybolt Universal Viscosity or to Saybolt Furol Viscosity
- D2270** Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 °C and 100 °C
- D2501** Test Method for Calculation of Viscosity-Gravity Constant (VGC) of Petroleum Oils
- D2622** Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry
- D2887** Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
- D2896** Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration
- D3120** Test Method for Trace Quantities of Sulfur in Light Liquid Petroleum Hydrocarbons by Oxidative Microcoulometry
- D3339** Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration
- D3828** Test Methods for Flash Point by Small Scale Closed Cup Tester
- D4052** Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter
- D4057** Practice for Manual Sampling of Petroleum and Petroleum Products
- D4059** Test Method for Analysis of Polychlorinated Biphenyls in Insulating Liquids by Gas Chromatography
- D4175** Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
- D4177** Practice for Automatic Sampling of Petroleum and Petroleum Products
- D4291** Test Method for Trace Ethylene Glycol in Used Engine Oil
- D4294** Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry
- D4530** Test Method for Determination of Carbon Residue (Micro Method)
- D4628** Test Method for Analysis of Barium, Calcium, Magnesium, and Zinc in Unused Lubricating Oils by Atomic Absorption Spectrometry
- D4629** Test Method for Trace Nitrogen in Liquid Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection
- D4739** Test Method for Base Number Determination by Potentiometric Hydrochloric Acid Titration
- D4927** Test Methods for Elemental Analysis of Lubricant and Additive Components—Barium, Calcium, Phosphorus, Sulfur, and Zinc by Wavelength-Dispersive X-Ray Fluorescence Spectroscopy
- D4929** Test Method for Determination of Organic Chloride Content in Crude Oil
- D4951** Test Method for Determination of Additive Elements in Lubricating Oils by Inductively Coupled Plasma Atomic Emission Spectrometry
- D5185** Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
- D5293** Test Method for Apparent Viscosity of Engine Oils and Base Stocks Between –10 °C and –35 °C Using Cold-Cranking Simulator
- D5453** Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence
- D5762** Test Method for Nitrogen in Liquid Hydrocarbons, Petroleum and Petroleum Products by Boat-Inlet Chemiluminescence
- D5800** Test Method for Evaporation Loss of Lubricating Oils by the Noack Method
- D5949** Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method)
- D5950** Test Method for Pour Point of Petroleum Products (Automatic Tilt Method)
- D5984** Test Method for Semi-Quantitative Field Test Method for Base Number in New and Used Lubricants by Color-Indicator Titration
- D5985** Test Method for Pour Point of Petroleum Products (Rotational Method)
- D6160** Test Method for Determination of Polychlorinated Biphenyls (PCBs) in Waste Materials by Gas Chromatography
- D6304** Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
- D6375** Test Method for Evaporation Loss of Lubricating Oils by Thermogravimetric Analyzer (TGA) Noack Method
- D6417** Test Method for Estimation of Engine Oil Volatility by Capillary Gas Chromatography
- D6443** Test Method for Determination of Calcium, Chlorine, Copper, Magnesium, Phosphorus, Sulfur, and Zinc in Unused Lubricating Oils and Additives by Wavelength Dispersive X-ray Fluorescence Spectrometry (Mathematical Correction Procedure)
- D6481** Test Method for Determination of Phosphorus, Sulfur, Calcium, and Zinc in Lubrication Oils by Energy Dispersive X-ray Fluorescence Spectroscopy
- D6749** Test Method for Pour Point of Petroleum Products (Automatic Air Pressure Method)
- D6822** Test Method for Density, Relative Density, and API Gravity of Crude Petroleum and Liquid Petroleum Products by Thermohydrometer Method
- D6892** Test Method for Pour Point of Petroleum Products (Robotic Tilt Method)
- D7042** Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
- D7094** Test Method for Flash Point by Modified Continuously Closed Cup (MCCCFP) Tester
- D7095** Test Method for Rapid Determination of Corrosiveness to Copper from Petroleum Products Using a Disposable Copper Foil Strip

- D7279** Test Method for Kinematic Viscosity of Transparent and Opaque Liquids by Automated Houillon Viscometer
- D7346** Test Method for No Flow Point and Pour Point of Petroleum Products and Liquid Fuels
- D7419** Test Method for Determination of Total Aromatics and Total Saturates in Lube Basestocks by High Performance Liquid Chromatography (HPLC) with Refractive Index Detection
- D7500** Test Method for Determination of Boiling Range Distribution of Distillates and Lubricating Base Oils—in Boiling Range from 100 °C to 735 °C by Gas Chromatography
- D7751** Test Method for Determination of Additive Elements in Lubricating Oils by EDXRF Analysis
- D7777** Test Method for Density, Relative Density, or API Gravity of Liquid Petroleum by Portable Digital Density Meter
- E1687** Test Method for Determining Carcinogenic Potential of Virgin Base Oils in Metalworking Fluids

### 2.2 Government Standard:

- EPA 8120** Chlorinated Hydrocarbons by GC/MS, EPA SW-846<sup>3</sup>

### 2.3 Other Standards:

- IP 346** Determination of Polycyclic Aromatics in Unused Lubricating Base Oils and Asphaltene Free Petroleum Fractions—Dimethyl Sulphoxide Extraction Refractive Index Method<sup>4</sup>
- IP 447** Petroleum Products—Determination of Sulfur Content—Wavelength-dispersive X-ray Fluorescence Spectrometry<sup>4</sup>
- IP 510** Petroleum Products—Determination of Organic Halogen Content—Oxidative Microcoulometric Method<sup>4</sup>

## 3. Terminology

### 3.1 Definitions:

3.1.1 For definitions of standard terms used in this guide, see Terminology **D4175** or ASTM Dictionary of Engineering Science and Technology.

3.1.2 *base oil, n*—a base stock or a blend of two or more base stocks used to produce finished lubricants, usually in combination with additives.

3.1.3 *base stock, n*—a hydrocarbon lubricant component, other than an additive, that is produced by a single manufacturer to the same specifications (independent of feed source or manufacturer's location), and that is identified by a unique formula number or product identification number, or both.

3.1.4 *guide, n*—a series of options or instructions that do not recommend a specific course of action.

3.1.4.1 *Discussion*—Whereas a practice describes a general usage principle, a guide only suggests an approach. The purpose of a guide is to offer guidance, based on a consensus of viewpoints, but not to establish a fixed procedure. A guide is

<sup>3</sup> U.S. EPA, "Test Methods for Evaluating Solid Waste, Physical/Chemical," SW-846. Available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.

<sup>4</sup> *Standard Methods for Analysis and Testing of Petroleum and Related Products*, Available from Energy Institute, London, 61 New Cavendish St., W1G 7AR, U.K., England. <http://www.energyinst.org>.

intended to increase the awareness of the user to available techniques in a given subject area and to provide information from which subsequent evaluation and standardization can be derived.

## 4. Significance and Use

4.1 Refinery and re-refinery feedstock and the processes to which the feed is subject determine the composition of the base stock produced. Once produced, other potential sources of variation include storage, transportation and blending. It follows that lubricating base oils will be of variable chemical composition. For this reason, characterization criteria for hydrocarbon lubricant base oils are frequently chosen from properties such as those listed in **Table 1** and/or **Table 2**. If specification limits are established, they are usually related to the intended use of the base oil.

4.2 The consistent performance of hydrocarbon lubricant base oils is a critical factor in a wide variety of applications such as engine oils, industrial lubricants, and metalworking fluids. In addition, in many of these applications humans are exposed to the base oils as a component of a formulated product such that health or safety considerations may need to be addressed. This guide suggests a compilation of properties and potential contaminants that are understood by those knowledgeable in the manufacture and use of hydrocarbon lubricants to be significant in some or all applications. A discussion of each of the suggested properties and potential contaminants is provided in **Appendix X2**, with each listed alphabetically within four categories.

4.3 The test methods, base oil properties, and potential contaminants suggested are those that would likely be useful in many common situations, although it is recognized that there are specific applications and situations that could have different requirements. Performance testing related to a specific application may serve as the basis for acceptability.

4.4 Issues such as frequency of testing and the specifics of how the test results are to be applied are not addressed in detail. It is the responsibility of the buyer and seller to determine and agree upon the implementation of this guide. This guide serves as a basis for that discussion.

## 5. Sampling

5.1 Sampling of lubricant base oils may be required as part of the buyer/seller arrangement. If a sampling program is required, sampling in accordance with Practice **D4057**, **D4177**, or a suitable alternative may be employed.

## 6. Procedure

### 6.1 Application of Guide:

6.1.1 This guide applies only to hydrocarbon lubricant base oils. Base oils containing detectable levels of esters, animal fats, vegetable oils, or other materials used as, or blended into, lubricants are not covered by this guide.

6.1.2 The frequency and extent of testing is to be determined based upon need. A property that can be shown to have minimal variation with time, a potential contaminant that can be shown to be consistently absent or at levels below concern,