



# 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

## 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 and health 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.

Current edition approved April 1, 2015. Published May 2015. Originally approved in 1998. Last previous edition approved in 2008 as D6074 – 08. DOI: 10.1520/D6074-15.

## 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 Charts for Liquid Petroleum 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 (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

<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.

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

- D2270** Practice for Calculating Viscosity Index from Kinematic Viscosity at 40 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, Petroleum Products, 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 Petroleum 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 Methods 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 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
- 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 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

<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>.

**TABLE 1 Suggested Physical and Compositional Property Test Methods for Lubricant Base Oils<sup>A,B</sup>**

Property	Test Method
<b>Physical properties</b>	
Appearance	c
Color	D1500
Density at 15 °C, kg/m <sup>3</sup>	D287, D1298, D4052, D6822, D7777
Flash point, °C	D92, D93, D3828, D7094
Kinematic viscosity at 40 °C and 100 °C, mm <sup>2</sup> /s (cSt)	D445, D7042, D7279
Apparent viscosity between -5 °C and -35 °C	D5293
Viscosity-gravity constant	D2501
Pour point, °C	D97, D5949, D5950, D5985, D6749, D6892, D7346
Viscosity index	D2270
Volatility at 371 °C, percent off	D2887, D6417, D7500
Percent Evaporation loss	D5800, D6375
Water separability (demulsibility), 30 min, mL	D1401
<b>Compositional properties</b>	
Carbon residue, percent mass	D189, D524, D4530
Nitrogen, mg/kg	D4629, D5762
Precipitation number	D91
Saturates, mass percent	D2007, D7419
Sulfur, mass percent	D2622, D3120, D4294, D5453, IP 447

<sup>A</sup> Specific application issues such as selection of tests, frequency of testing, and test levels are to be negotiated between the base oil buyer and the seller.

<sup>B</sup> See **Appendix X2** for a discussion of each property.

<sup>C</sup> Refer to **X2.1.1** for a discussion of this property.