



# Standard Practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment<sup>1</sup>

This standard is issued under the fixed designation D6224; 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.

## INTRODUCTION

A more systematic approach to monitoring auxiliary power plant equipment can help to minimize the high cost of oil changes and unplanned shutdowns. These avoided costs must be balanced against the cost of sampling and laboratory testing.

This practice is designed to help the user evaluate the condition of the lubricant through its life cycle by carrying out a meaningful program of sampling and testing of oils in use. This practice is performed in order to collect data and monitor trends which suggest any signs of lubricant deterioration and to ensure a safe, reliable, and cost-effective operation of the monitored plant equipment.

## 1. Scope\*

1.1 This practice covers the requirements for the effective monitoring of mineral oil and phosphate ester fluid lubricating oils in service auxiliary (non-turbine) equipment used for power generation. Auxiliary equipment covered includes gears, hydraulic systems, diesel engines, pumps, compressors, and electrohydraulic control (EHC) systems. It includes sampling and testing schedules and recommended action steps, as well as information on how oils degrade.

NOTE 1—Other types of synthetic lubricants are sometimes used but are not addressed in this practice because they represent only a small fraction of the fluids in use. Users of these fluids should consult the manufacturer to determine recommended monitoring practices.

1.2 This practice does not cover the monitoring of lubricating oil for steam and gas turbines. Rather, it is intended to complement Practice [D4378](#).

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 and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards*:<sup>2</sup>

- [D92 Test Method for Flash and Fire Points by Cleveland Open Cup Tester](#)
- [D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation](#)
- [D257 Test Methods for DC Resistance or Conductance of Insulating Materials](#)
- [D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids \(and Calculation of Dynamic Viscosity\)](#)
- [D664 Test Method for Acid Number of Petroleum Products by Potentiometric Titration](#)
- [D665 Test Method for Rust-Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water](#)
- [D892 Test Method for Foaming Characteristics of Lubricating Oils](#)
- [D893 Test Method for Insolubles in Used Lubricating Oils](#)
- [D943 Test Method for Oxidation Characteristics of Inhibited Mineral Oils](#)
- [D974 Test Method for Acid and Base Number by Color-Indicator Titration](#)
- [D1169 Test Method for Specific Resistance \(Resistivity\) of Electrical Insulating Liquids](#)
- [D1298 Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method](#)

<sup>1</sup> This practice is under the jurisdiction of ASTM Committee [D02](#) on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee [D02.C0.01](#) on Turbine Oil Monitoring, Problems and Systems.

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<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

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

**D1500** Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)

**D1533** Test Method for Water in Insulating Liquids by Coulometric Karl Fischer Titration

**D2272** Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel

**D2273** Test Method for Trace Sediment in Lubricating Oils

**D2422** Classification of Industrial Fluid Lubricants by Viscosity System

**D2668** Test Method for 2,6-*di-tert*-Butyl- *p*-Cresol and 2,6-*di-tert*-Butyl Phenol in Electrical Insulating Oil by Infrared Absorp

**D2896** Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration

**D2982** Test Methods for Detecting Glycol-Base Antifreeze in Used Lubricating Oils

**D3427** Test Method for Air Release Properties of Hydrocarbon Based Oils

**D3524** Test Method for Diesel Fuel Diluent in Used Diesel Engine Oils by Gas Chromatography

**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

**D4378** Practice for In-Service Monitoring of Mineral Turbine Oils for Steam, Gas, and Combined Cycle Turbines

**D4739** Test Method for Base Number Determination by Potentiometric Hydrochloric Acid Titration

**D5185** Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)

**D6304** Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration

**D6810** Test Method for Measurement of Hindered Phenolic Antioxidant Content in Non-Zinc Turbine Oils by Linear Sweep Voltammetry

**D6971** Test Method for Measurement of Hindered Phenolic and Aromatic Amine Antioxidant Content in Non-zinc Turbine Oils by Linear Sweep Voltammetry

**D7155** Practice for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils

**D7414** Test Method for Condition Monitoring of Oxidation in In-Service Petroleum and Hydrocarbon Based Lubricants by Trend Analysis Using Fourier Transform Infrared (FT-IR) Spectrometry

**D7546** Test Method for Determination of Moisture in New and In-Service Lubricating Oils and Additives by Relative Humidity Sensor

**D7464** Practice for Manual Sampling of Liquid Fuels, Associated Materials and Fuel System Components for Microbiological Testing

**D7647** Test Method for Automatic Particle Counting of Lubricating and Hydraulic Fluids Using Dilution Tech-

niques to Eliminate the Contribution of Water and Interfering Soft Particles by Light Extinction

**D7669** Guide for Practical Lubricant Condition Data Trend Analysis

**D7687** Test Method for Measurement of Cellular Adenosine Triphosphate in Fuel, Fuel/Water Mixtures, and Fuel-Associated Water with Sample Concentration by Filtration

**D7720** Guide for Statistically Evaluating Measurand Alarm Limits when Using Oil Analysis to Monitor Equipment and Oil for Fitness and Contamination

**D7843** Test Method for Measurement of Lubricant Generated Insoluble Color Bodies in In-Service Turbine Oils using Membrane Patch Colorimetry

**D7978** Test Method for Determination of the Viable Aerobic Microbial Content of Fuels and Associated Water—Thixotropic Gel Culture Method

**E1064** Test Method for Water in Organic Liquids by Coulometric Karl Fischer Titration

**F311** Practice for Processing Aerospace Liquid Samples for Particulate Contamination Analysis Using Membrane Filters

**F312** Test Methods for Microscopical Sizing and Counting Particles from Aerospace Fluids on Membrane Filters

## 2.2 ISO Standard:<sup>3</sup>

**ISO 3448:1992** Industrial liquid lubricants—ISO viscosity classification

**ISO 4406:1999** Hydraulic fluid power—Fluids—Method for coding the level of contamination by solid particles

## 2.3 SAE Standards:<sup>4</sup>

**J300** Engine Oil Viscosity Classification

**J306** Automotive Gear Lubricant Viscosity Classification

## 3. Significance and Use

3.1 This practice is intended to help users, particularly power plant operators, maintain effective control over their mineral lubricating oils and lubrication monitoring program. This practice may be used to perform oil changes based on oil condition and test results rather than on the basis of service time or calendar time. It is intended to save operating and maintenance expenses.

3.2 This practice is also intended to help users monitor the condition of mineral lubricating oils and guard against excessive component wear, oil degradation, or contamination, thereby minimizing the potential of catastrophic machine problems that are more likely to occur in the absence of such an oil condition monitoring program.

3.3 This practice does not necessarily reference all of the current oil testing technologies and is not meant to preclude the use of alternative instrumentation or test methods that provide meaningful or trendable test data, or both. Some oil testing devices and sensors (typically used for screening oils that will be tested according to standard methods) provide trendable

<sup>3</sup> Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

<sup>4</sup> Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, <http://www.sae.org>.

indicators that correlate to water, particulates, and other contaminants but do not directly measure these.

3.4 This practice is intended for mineral oil products, and not for synthetic type of products, with the exception of phosphate esters fluids typically used in power plant control systems.

#### 4. General Properties of Lubricating Oils

4.1 In general, lubricating oils are designed to reduce friction and wear, provide cooling, control deposits, and combat the effects of contamination. A base oil's lubricating properties are enhanced by selected additives. Different machines have different lubricant additive requirements, some of which are described in this section. Proper lubrication minimizes or precludes contact between metal surfaces and reduces component wear.

4.2 *Gear Oils*—The primary requirement of gear oils is that they prevent wear and minimize other forms of damage such as pitting and scuffing by maintaining a lubricant film between the moving surfaces.

4.3 *Hydraulic Oils*—A hydraulic fluid is required to transmit hydraulic pressure and energy, minimize friction and wear in pumps, valves, and cylinders, and protect metal surfaces against corrosion. To obtain optimum efficiency of machine operation and control, the viscosity of the oil should be low enough to minimize frictional and pressure losses in piping. However, it also is necessary to have a sufficiently high viscosity to provide satisfactory wear protection and minimize leakage of the fluid. High-viscosity index fluids help to maintain a satisfactory viscosity over a wide temperature range. The anti-wear properties of high-quality hydraulic oils usually are improved by suitable additives. Since the clearances in pumps and valves tend to be critical, it is important to provide adequate filtration equipment (full flow or bypass, or both) to maintain a minimum particle content and thus minimize wear. The antioxidant additives in the hydraulic oil should give the oil good oxidation stability to avoid the formation of insoluble gums or sludges; the oil should have good water separation properties, and, because air may be entrained in the system, the oil should have good air-release properties and resistance to foaming. Similarly, good rust protection properties will assist in keeping system metals in satisfactory condition.

4.4 *Diesel Engine Oils*—In addition to the typical role of lubricating oils which is to lubricate, clean, cool and seal, diesel engine oils are formulated to provide protection from acids and disperse soot particles that are created during the combustion process. Diesel engine oils are compounded with alkaline additives to neutralize the sulfuric acids that are produced when the diesel fuel is combusted. They are also compounded with dispersant/detergents to keep the engine clean and the by-products of combustion (fuel soot) suspended. The combination of wear regimes found in the diesel engine require the lubricants to have high levels of anti-wear additives to protect the engine from wear during the most severe condition. Multi-grade lubricants (high viscosity index) are often employed in diesel engine lubricants that are required to operate over a wide temperature range.

4.5 *Turbine Oils or Circulating Oils, or Both*—These oils provide satisfactory lubrication and cooling of bearings and gears (for example, in auxiliary turbines, pumps and gearboxes as circulating oils). They also can function as a governor hydraulic fluid. The oil must have a viscosity high enough to maintain a sufficiently thick film of oil on load-bearing surfaces, but low enough to minimize energy losses while providing adequate cooling. These oils are recommended where the degree of loading on bearings and gears is less than in gear oil applications. Turbine or circulating oils, or both, have excellent oxidation resistance and contain rust inhibitors; they are often referred to as rust and oxidation inhibited (R&O) oils. They can also contain additives to improve water separability and decrease foaming tendency.

4.6 *Compressor Oils*—In addition to possessing the correct viscosity for satisfactory bearing and cylinder lubrication, particularly for air compressors, very good oxidation resistance is required to avoid degradation of the lubricant in the presence of heated air. This is particularly important for mineral oils where discharge temperatures are high, since carbon and oxidized oil deposits may autoignite if exposed continuously to temperatures above 148 °C. The fire potential that exists under these conditions make low volatility and high auto-ignition values equally or more important than high-flash or fire points. In compressor lubrication, condensed water is present frequently. For this reason, the oil must possess properties that ensure that the oil rather than water wets the metal surfaces. Also, to avoid the accumulation of water-in-oil emulsions in the after coolers, the water should separate out rather than form an emulsion.

4.7 *Electrohydraulic Control (EHC) Fluids*—Triaryl phosphate ester EHC fluids are inherently fire-resistant and maintain this property throughout their service life. The very low vapor pressure and chemical nature of these fluids result in high flash point, fire point, and autoignition temperature. EHC fluids should be continuously purified using bypass systems to maintain acid number, moisture, and particulates at low levels. Moisture can cause hydrolysis of EHC fluids which results in elevated acid number. Components constructed of copper and lead alloys should be avoided. These fluids are chemically different from mineral oils; consequently, the interpretation of test results will be significantly different. The fluid supplier should be consulted if there is a question about interpretation of analytical results.

#### 5. Operational Factors Affecting the Service Life of Oils

5.1 *New Oil Quality and Suitability for Intended Use*—Use of high-quality oils that meet recognized standards (such as manufacturer military specifications and OEM specifications) is the best assurance of potentially long service life. Careful oil storage is important to prevent the degradation of the lubricant while in storage or being dispensed. Accurate labeling of lubricant containers is vital to ensure proper identification.

5.1.1 Viscosity is the most important characteristic of an oil. Oil load bearing and lubricating properties are related to its viscosity. The use of oil with incorrect viscosity can increase wear rates, heat build-up, and lube degradation. In extreme