Designation: D8506 – 23

Standard Guide for Microbial Contamination and Biodeterioration in Turbine Oils and Turbine Oil Systems[1]

This standard is issued under the fixed designation D8506; 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 (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide provides personnel who have a limited microbiological background with an understanding of the symptoms, occurrence, and consequences of chronic microbial contamination. The guide also suggests means for detection and control of microbial contamination in turbine oils and turbine oil systems. This guide applies primarily to turbine lubricants (see Specifications D4293 and D4304) and turbine oil systems. However, the principles discussed herein also apply generally to lubricating oils with viscosities <100 mm^2/s (for example, see Specification D6158).

1.2 This guide focuses on turbine system and turbine oil microbiology. Despite considerable differences in turbine systems (for example, gas and steam driven turbines; power generation and propulsion; etc.) as ecosystems for microbial communities – with the exception of temperature – these differences are largely irrelevant. Ambient temperatures are typically similar. Recirculating turbine oil temperatures are commonly >40 °C. However, generally speaking, all systems in which accumulations of free water can develop, share properties that are considered in this guide.

1.2.1 Steam turbines, and to a greater extent hydro turbines, are continuously exposed to water ingression. Diligence is needed to ensure seals and bearings are in good condition to prevent water ingression or conditions that are conducive to biodeterioration. However, due to the risk of the accumulation of condensation, all equipment can become susceptible when shut down for extended periods.

1.3 This guide complements Energy Institute's Guidelines on detecting, controlling, and mitigating microbial growth in oils and fuels used at power generation facilities (2.2). The Energy Institute's guidance document provides greater detail than the overview provided in this guide.

1.4 Microbial contamination in turbine oil systems shares common features with microbial contamination in fuel systems (See Guide D6469). However, there are also relevant differences. Although the chemistry of the fluids is different, this Guide draws heavily on D6469 but highlights unique aspects of turbine oil and turbine oil system biodeterioration and microbial contamination.

1.5 This guide is not a compilation of all of the concepts and terminology used by microbiologists. It provides basic explanations of microbial contamination and biodeterioration in turbine oils and turbine oil systems.

1.6 The values in SI units are to be regarded as the standard.

1.7 *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.*

1.8 *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:*[2]

D130 Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

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

D888 Test Methods for Dissolved Oxygen in Water

D892 Test Method for Foaming Characteristics of Lubricating Oils

D943 Test Method for Oxidation Characteristics of Inhibited Mineral Oils

[1] 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.C0.01 on Turbine Oil Monitoring, Problems and Systems.

Current edition approved June 15, 2023. Published July 2023. DOI: 10.1520/D8506-23.

[2] 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.

D974 Test Method for Acid and Base Number by Color-Indicator Titration
D1067 Test Methods for Acidity or Alkalinity of Water
D1293 Test Methods for pH of Water
D1331 Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials
D1401 Test Method for Water Separability of Petroleum Oils and Synthetic Fluids
D1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)
D1744 Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent (Withdrawn 2016)[3]
D1976 Test Method for Elements in Water by Inductively-Coupled Plasma Atomic Emission Spectroscopy
D2068 Test Method for Determining Filter Blocking Tendency
D2272 Test Method for Oxidation Stability of Steam Turbine Oils by Rotating Pressure Vessel
D2273 Test Method for Trace Sediment in Lubricating Oils (Withdrawn 2022)[3]
D2896 Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration
D3326 Practice for Preparation of Samples for Identification of Waterborne Oils
D3328 Test Methods for Comparison of Waterborne Petroleum Oils by Gas Chromatography
D3339 Test Method for Acid Number of Petroleum Products by Semi-Micro Color Indicator Titration
D3870 Practice for Establishing Performance Characteristics for Colony Counting Methods in Microbiology (Withdrawn 2000)[3]
D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
D4293 Specification for Phosphate Ester-Based Fluids for Turbine Lubrication and Steam Turbine Electro-Hydraulic Control (EHC) Applications
D4304 Specification for Mineral and Synthetic Lubricating Oil Used in Steam or Gas Turbines
D4310 Test Method for Determination of Sludging and Corrosion Tendencies of Inhibited Mineral Oils
D4378 Practice for In-Service Monitoring of Mineral Turbine Oils for Steam, Gas, and Combined Cycle Turbines
D4412 Test Methods for Sulfate-Reducing Bacteria in Water and Water-Formed Deposits
D4454 Test Method for Simultaneous Enumeration of Total and Respiring Bacteria in Aquatic Systems by Microscopy (Withdrawn 2015)[3]
D4840 Guide for Sample Chain-of-Custody Procedures
D4898 Test Method for Insoluble Contamination of Hydraulic Fluids by Gravimetric Analysis
D5185 Test Method for Multielement Determination of Used and Unused Lubricating Oils and Base Oils by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES)
D5392 Test Method for Isolation and Enumeration of ***Escherichia coli*** in Water by the Two-Step Membrane Filter Procedure
D6158 Specification for Mineral Hydraulic Oils
D6224 Practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment
D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration
D6439 Guide for Cleaning, Flushing, and Purification of Steam, Gas, and Hydroelectric Turbine Lubrication Systems
D6469 Guide for Microbial Contamination in Fuels and Fuel Systems
D7155 Practice for Evaluating Compatibility of Mixtures of Turbine Lubricating Oils
D7464 Practice for Manual Sampling of Liquid Fuels, Associated Materials and Fuel System Components for Microbiological Testing
D7669 Guide for Practical Lubricant Condition Data Trend Analysis
D7687 Test Method for Measurement of Cellular Adenosine Triphosphate in Fuel 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
D7847 Guide for Interlaboratory Studies for Microbiological Test Methods
D7978 Test Method for Determination of the Viable Aerobic Microbial Content of Fuels and Associated Water—Thixotropic Gel Culture Method
D8112 Guide for Obtaining In-Service Samples of Turbine Operation Related Lubricating Fluid
E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
E1326 Guide for Evaluating Non-culture Microbiological Tests
E1542 Terminology Relating to Occupational Health and Safety
E2551 Test Methods for Humidity Calibration (or Conformation) of Humidity Generators for Use with Thermogravimetric Analyzers
E2756 Terminology Relating to Antimicrobial and Antiviral Agents

2.2 *Energy Institute Standards:*[4]
IP 613 Determination of the viable aerobic microbial content of fuels and associated water - Thixotropic Gel Culture Method Guidelines on detecting, controlling, and mitigating microbial growth in oils and fuels used at power generation facilities.

[3] The last approved version of this historical standard is referenced on www.astm.org.

[4] Available from Energy Institute, 61 New Cavendish St., London, WIG 7AR, U.K. https://publishing.energyinst.org/ip-test-methods.

2.3 *Government Standards:*

40 CFR 152 Pesticide Registration and Classification Procedures[5]

EU Biocides Regulation (528/2012)[6]

2.4 *ISO Standards:*[7]

ISO 3722 Hydraulic fluid power – Fluid sample containers — Qualifying and controlling cleaning methods

ISO 4406 Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles, Second Edition, 1999

ISO 4407 Hydraulic Fluid Power – Fluid Contamination – Determination of Particulate Contamination by Counting Method Using an Optical Microscope, Second Edition, 2002

ISO 11500 Hydraulic fluid power – Determination of the particulate contamination level of a liquid sample by automatic particle counting using the light extinction, Second Edition, 2008

ISO 11171 Hydraulic Fluid Power – Calibration of automatic particle counters for liquids

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions and terms relating to this guide, refer to Terminologies D4175, E1542, and E2756. Selected terms from these Terminology Standards are included for the benefit of readers who are unfamiliar with microbiology terms.

3.1.2 *aerobe, n*—an organism that requires oxygen to remain metabolically active.

3.1.2.1 *Discussion*—Aerobes use oxygen as their terminal electron acceptor in their primary energy-generating metabolic pathways. Aerobes require oxygen for survival, using *aerobic* metabolic processes to generate energy for growth and survival.

3.1.3 *aggressiveness index (A.I.), n*—the value computed from the sum of the pH + log alkalinity + log hardness of water sample where both alkalinity and hardness are reported as milligram $CaCO_3$ L^{-1}.

3.1.3.1 *Discussion*—As A.I. decreases, water becomes more corrosive. At A.I. ≥ 12, water is noncorrosive. At 10 ≤ A.I. < 12, water is moderately corrosive. At A.I. < 10, water is strongly corrosive.

3.1.4 *anaerobe, n*—an organism that cannot grow or proliferate in the presence of oxygen.

3.1.4.1 *Discussion*—Anaerobes use molecules other than oxygen in their primary energy-generating metabolic pathways, such as sulfate, nitrate, ketones, and other high-energy organic molecules. Although anaerobes may survive in the presence of oxygen, anaerobic growth typically occurs only in an oxygen depleted environment.

3.1.5 *anoxic, adj*—oxygen free.

3.1.6 *antimicrobial, n*—see biocide.

3.1.7 *bacterium (pl. bacteria), n*—a single cell microorganism characterized by the absence of defined intracellular membranes that define all higher life forms.

3.1.7.1 *Discussion*—All bacteria are members of the biologically diverse kingdoms *Prokaryota* and *Archaebacteriota*. Individual taxa within these kingdoms are able to thrive in environments ranging from sub-zero temperatures, such as in frozen foods and polar ice, to superheated waters in deep-sea thermal vents, and over the pH range < 2.0 to > 13.0. Potential food sources range from single carbon molecules (carbon dioxide and methane) to complex polymers, including plastics. Oxygen requirements range from obligate anaerobes, which die on contact with oxygen, to obligate aerobes, which die if oxygen pressure falls below a species-specific threshold.

3.1.8 *bioburden, n*—the level of microbial contamination (*biomass*) in a system.

3.1.8.1 *Discussion*—Typically, bioburden is defined in terms of either biomass or numbers of cells per unit volume or mass or surface area material tested (g biomass / mL; g biomass / g; cells / mL sample, and so forth). The specific parameter used to define bioburden depends on critical properties of the system evaluated and the investigator's preferences.

3.1.9 *biocide, n*—a physical or chemical agent that kills living organisms.

3.1.9.1 *Discussion*—Biocides are further classified as bactericides (kill bacteria), fungicides (kill fungi), and microbicides (kill both bacterial and fungi). They are also referred to as *antimicrobials*.

3.1.10 *biodeterioration, n*—the loss of commercial value or performance characteristics, or both, of a product or material through biological processes.

3.1.10.1 *Discussion*—In turbine oil systems, turbine oil is the product and turbine oil system components such as filter media, transfer lines, heat exchangers, reservoirs, etc. are the materials.

3.1.11 *biofilm, n*—a film or layer of microorganisms, biopolymers, water, and entrained organic and inorganic debris that forms as a result of microbial growth and proliferation at phase interfaces (liquid-liquid, liquid-solid, liquid-gas, and so forth) (synonym: *skinnogen layer*).

3.1.12 *biomass, n*—biological material including any material other than fossil fuels which is or was a living organism or component or product of a living organism.

3.1.12.1 *Discussion*—In biology and environmental science, biomass is typically expressed as density of biological material per unit sample volume, area, or mass (g biomass/g (or /mL or /cm^2) sample); when used for products derived from organisms biomass is typically expressed in terms of mass (kg, MT, etc.) or volume (L, m^3, bbl, etc.).

3.1.13 *biosurfactant, n*—a biologically produced molecule that acts as a soap or detergent.

[5] Available from U.S. Government Printing Office, Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401. https://ecfr.io/Title-40/Part-152.

[6] Available from http://eur-lex.europa.eu/JOHtml.do?uri=OJ:L:2012:167:SOM:EN:HTML.

[7] Available from International Standards Organization, ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva Switzerland https://www.iso.org/standards.html.