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Standard Guide for Statistically Evaluating Measurand Alarm Limits when Using Oil Analysis to Monitor Equipment and Oil for Fitness and Contamination¹

This standard is issued under the fixed designation D7720; 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 specific requirements to statistically evaluate measurand alarm thresholds, which are called alarm limits, as they are applied to data collected from in-service oil analysis. These alarm limits are typically used for condition monitoring to produce severity indications relating to states of machinery wear, oil quality, and system contamination. Alarm limits distinguish or separate various levels of alarm. Four levels are common and will be used in this guide, though three levels or five levels can also be used.

1.2 A basic statistical process control technique described herein is recommended to evaluate alarm limits when measurand data sets may be characterized as both parametric and in control. A frequency distribution for this kind of parametric data set fits a well-behaved two-tail normal distribution having a “bell” curve appearance. Statistical control limits are calculated using this technique. These control limits distinguish, at a chosen level of confidence, signal-to-noise ratio for an in-control data set from variation that has significant, assignable causes. The operator can use them to objectively create, evaluate, and adjust alarm limits.

1.3 A statistical cumulative distribution technique described herein is also recommended to create, evaluate, and adjust alarm limits. This particular technique employs a percent cumulative distribution of sorted data set values. The technique is based on an actual data set distribution and therefore is not dependent on a presumed statistical profile. The technique may be used when the data set is either parametric or nonparametric, and it may be used if a frequency distribution appears skewed or has only a single tail. Also, this technique may be used when the data set includes special cause variation in addition to common cause variation, although the technique should be repeated when a special cause changes significantly or is eliminated. Outputs of this technique are specific mea-

surand values corresponding to selected percentage levels in a cumulative distribution plot of the sorted data set. These percent-based measurand values are used to create, evaluate and adjust alarm limits.

1.4 This guide may be applied to sample data from testing of in-service lubricating oil samples collected from machinery (for example, diesel, pumps, gas turbines, industrial turbines, hydraulics) whether from large fleets or individual industrial applications.

1.5 This guide may also be applied to sample data from testing in-service oil samples collected from other equipment applications where monitoring for wear, oil condition, or system contamination are important. For example, it may be applied to data sets from oil filled transformer and circuit breaker applications.

1.6 Alarm limit evaluating techniques, which are not statistically based are not covered by this guide. Also, the techniques of this standard may be inconsistent with the following alarm limit selection techniques: “rate-of-change,” absolute alarming, multi-parameter alarming, and empirically derived alarm limits.

1.7 The techniques in this guide deliver outputs that may be compared with other alarm limit selection techniques. The techniques in this guide do not preclude or supersede limits that have been established and validated by an Original Equipment Manufacturer (OEM) or another responsible party.

1.8 *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.*

1.9 *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.*

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 D02.96.04 on Guidelines for In-Service Lubricants Analysis.

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

2. Referenced Documents

2.1 ASTM Standards:²

- 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
- D974 Test Method for Acid and Base Number by Color-Indicator Titration
- D2896 Test Method for Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration
- D4175 Terminology Relating to Petroleum Products, Liquid Fuels, and Lubricants
- D4378 Practice for In-Service Monitoring of Mineral Turbine Oils for Steam, Gas, and Combined Cycle Turbines
- D4928 Test Method for Water in Crude Oils by Coulometric Karl Fischer 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)
- D6224 Practice for In-Service Monitoring of Lubricating Oil for Auxiliary Power Plant Equipment
- D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance
- 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
- D6595 Test Method for Determination of Wear Metals and Contaminants in Used Lubricating Oils or Used Hydraulic Fluids by Rotating Disc Electrode Atomic Emission Spectrometry
- D6786 Test Method for Particle Count in Mineral Insulating Oil Using Automatic Optical Particle Counters
- D7042 Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
- D7279 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids by Automated Houillon Viscometer
- 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
- D7416 Practice for Analysis of In-Service Lubricants Using a Particular Five-Part (Dielectric Permittivity, Time-Resolved Dielectric Permittivity with Switching Magnetic Fields, Laser Particle Counter, Microscopic Debris Analysis, and Orbital Viscometer) Integrated Tester
- D7483 Test Method for Determination of Dynamic Viscosity

and Derived Kinematic Viscosity of Liquids by Oscillating Piston Viscometer

- D7484 Test Method for Evaluation of Automotive Engine Oils for Valve-Train Wear Performance in Cummins ISB Medium-Duty Diesel Engine
- D7596 Test Method for Automatic Particle Counting and Particle Shape Classification of Oils Using a Direct Imaging Integrated Tester
- D7647 Test Method for Automatic Particle Counting of Lubricating and Hydraulic Fluids Using Dilution Techniques to Eliminate the Contribution of Water and Interfering Soft Particles by Light Extinction
- D7670 Practice for Processing In-service Fluid Samples for Particulate Contamination Analysis Using Membrane Filters
- D7684 Guide for Microscopic Characterization of Particles from In-Service Lubricants
- D7685 Practice for In-Line, Full Flow, Inductive Sensor for Ferromagnetic and Non-ferromagnetic Wear Debris Determination and Diagnostics for Aero-Derivative and Aircraft Gas Turbine Engine Bearings
- D7690 Practice for Microscopic Characterization of Particles from In-Service Lubricants by Analytical Ferrography
- E2412 Practice for Condition Monitoring of In-Service Lubricants by Trend Analysis Using Fourier Transform Infrared (FT-IR) Spectrometry

3. Terminology

3.1 Definitions:

3.1.1 For definitions of terms used in this guide, refer to Terminology D4175.

3.1.2 *alarm, n*—means of alerting the operator that a particular condition exists.

3.1.3 *assignable cause, n*—factor that contributes to variation in a process or product output that is feasible to detect and identify; also called *special cause*.

3.1.4 *boundary lubrication, n*—condition in which the friction and wear between two surfaces in relative motion are determined by the properties of the surfaces and the properties of the contacting fluid, other than bulk viscosity.

3.1.4.1 *Discussion*—Metal to metal contact occurs and the chemistry of the system is involved. Physically adsorbed or chemically reacted soft films (usually very thin) support contact loads. Consequently, some wear is inevitable.

3.1.5 *chance cause, n*—source of inherent random variation in a process which is predictable within statistical limits; also called *common cause*.

3.1.6 *characteristic, n*—property of items in a sample or population which, when measured, counted or otherwise observed, helps to distinguish between the items.

3.1.7 *data set, n*—logical collection of data that supports a user function and could include one or more data tables, files, or sources.

3.1.7.1 *Discussion*—Herein a data set is a population of values for a measurand from within a particular measurand set and covering an equipment population.

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.