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Standard Guide for Filter Debris Analysis (FDA) Using Manual or Automated Processes[1]

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INTRODUCTION

Typically, main lubrication systems incorporate in-system filters to maintain an appropriate lubricant cleanliness level during operation. Since the lubrication filter element removes and retains a major portion of the solid contamination in the lubrication system, evaluation of the debris captured within the filter element aids in the determination of machine condition and root cause analysis (RCA).

The past decade has seen more widespread use of filter debris analysis (FDA) as a condition-monitoring tool to detect and analyze abnormal contaminant ingression into the lube system and predict lube system component wear. This is in part due to the increased use of finer filtration in machinery which results in a decrease of wear debris available for detection by traditional sampled oil analysis. The U. S. military and other militaries around the world as well as Original Equipment Manufacturers have adopted FDA techniques. Commercial in-service oil laboratories are also utilizing a wide range of FDA techniques, from manual to automated. It is necessary to provide a guide to improve analysis and comparison of data.

1. Scope

1.1 This guide pertains to removal and analysis techniques to extract debris captured by in-service lubricant and hydraulic filters and to analyze the debris removed.

1.2 This guide suggests techniques to remove, collect and analyze debris from filters in support of machinery health condition monitoring.

1.3 Debris removal techniques range from manual to automated.

1.4 Analysis techniques vary from visual, particle counting, microscopic, x-ray fluorescence (XRF), atomic emission spectroscopy (AES), and scanning electron microscopy energy dispersive x-rays (SEMEDX).

1.5 This guide is suitable for use with the following filter types: screw on, metal mesh, and removable diagnostic layer filters.

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.*

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:*[2]

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

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

D7669 Guide for Practical Lubricant Condition Data Trend Analysis

[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 D02.96.06 on Practices and Techniques for Prediction and Determination of Microscopic Wear and Wear-related Properties.

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[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.

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
D7720 Guide for Statistically Evaluating Measurand Alarm Limits when Using Oil Analysis to Monitor Equipment and Oil for Fitness and Contamination
D7898 Practice for Lubrication and Hydraulic Filter Debris Analysis (FDA) for Condition Monitoring of Machinery

2.2 *Other Documents:*
TTCP-AER-TP3-TR01-2010 Filter Debris Analysis Guide, July 2010, published by The Technical Cooperation Program (TTCP)[3]
SAE AIR1828 Guide to Oil System Monitoring in Aircraft Gas Turbine Engines[4]

3. Terminology

3.1 *Definitions:*

3.1.1 *lubricant condition monitoring, n*—a field of technical activity in which selected physical parameters associated with an operating machine are periodically or continuously sensed, measured, and recorded for the interim purpose of reducing, analyzing, comparing, and displaying the data and information so obtained and for the ultimate purpose of using interim result to support decisions related to the operation and maintenance of the machine.

3.1.2 *machinery health, n*—a qualitative expression of the operational status of a machine sub-component, component, or entire machine, used to communicate maintenance and operational recommendations or requirements in order to continue operation, schedule maintenance, or take immediate maintenance action.

3.1.3 *prognostics, n*—a forecast of the condition or remaining usable life of a machine, fluid, or component part.

3.1.4 *remaining useful life, n*—a subjective estimate based upon observations, or average estimates of similar items, components, or systems, or a combination thereof, of the number of remaining time that an item, component, or system is estimated to be able to function in accordance with its intended purpose before replacement.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *filter debris analysis (FDA), n*—the analysis of debris specifically extracted from a system filter for the purpose of determining the health of the oil-wetted components within that system or the source of significant contaminants.

[3] Available from Technical Cooperation Program (TTCP), http://www.acq.osd.mil/ttcp/index.html.

[4] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096-0001, http://www.sae.org.

4. Summary of Guide

4.1 This guide provides practical guidance on filter debris analysis of in-service lubricant filters. Various techniques for debris removal, collection, and analysis are presented with their associated benefits and limitations.

5. Significance and Use

5.1 This guide is intended to provide machinery maintenance and monitoring personnel with a guideline for performing filter debris analysis as a means to determine machine condition. Correlating the filter contaminants to 'normal' and 'abnormal' lube system operation provides early indication of a contaminant or component wear related lube system problem. Analysis of the contaminant collected within the lube filter element provides a tool to identify the failure mode, its rate of progression, and the source of the contamination.

5.2 FDA differs from traditional oil analysis in that the filter is sampled instead of the fluid. Debris from the filter is removed for analysis. FDA is an effective means of monitoring equipment wear because the wear history is efficiently captured in the filter matrix. Typically, more than 95 % of all released metal particles larger than the filter pore size are captured in the filter (**1**).[5] In addition, other types of particulate contamination, including seal wear material and environmental contaminations are captured, which can also provide diagnostic information.

6. Interferences

6.1 *Time-on-Filter Information*—If the time-on-filter is not known, it is not possible to set limits for rate and severity of particulate generation.

6.2 *Analysis Techniques*—To compare filter debris from like equipment, the same filter extraction and analysis techniques must be utilized. Note some of the techniques in this guide are quite subjective such as visual analysis and manual extraction, which makes interpretation of results subjective.

6.3 *Operating Conditions*—Machine operational intensity impacts how quickly a component wears and how rapidly a fault progresses. Similar equipment operating under different conditions can generate different wear and be exposed to different contaminants. A relevant indicator of machine usage must be included in any trend and limit calculations. (See Guides D7669 and D7720.) The selected usage indicator must reflect actual machine usage, that is, life consumed for example, stop/start cycles, megawatt hours, hours of use, or fuel consumption.

6.4 *Maintenance Practices*—Care should be taken during removal of the filter to ensure that maintenance practices do not contaminate the filter.

7. Procedures

7.1 Typically, main lubrication systems incorporate in-system filters to maintain an appropriate lubricant cleanliness level during operation. The filter is incorporated either in the

[5] The boldface numbers in parentheses refer to the list of references at the end of this standard.