Used-Oil Evaluation — Trend Analysis

A tool to help assess the operating condition of both the jet engine oil system and the oil

ExxonMobil
Aviation Lubricants

Introduction

Viscosity, acid number and water are parameters that generally indicate the condition of the oil and lend themselves well to setting minimum/maximum limits. These limits are set by the equipment manufacturer or operator, not by the oil company. However, it is best to analyze used-oil data over a period of time on samples taken at periodic intervals. This is called trend analysis and is a useful approach for identifying problems early so that corrective action can be initiated before costly and catastrophic problems occur.

Wear metals are also part of the used oil analysis to indicate the changing condition of the various parts of the engine oil system. This includes oil pump, gears, bearings and other metallic parts that may rub and generate wear debris. It is important to establish a practical interval to extract oil samples from the engine so good baseline data is recorded. This baseline data can then be used for comparison purposes if failures produce increased wear metals. The interval should be tailored to the particular testing program to provide timely data for analysis.

In the aviation industry, metals analysis is also referred to as SOAP (Spectrometric Oil Analysis Program). The military has a similar acronym for this testing, called JOAP (Jet Oil Analysis Program). Most engine builders prefer that metals analysis interpretation be done on the basis of changes from "established trends" rather than relative to "threshold or control limits." Each engine type utilizes different types of metals and therefore will have different/unique wear patterns. These wear patterns will be specific to each engine, rather than the type of oil, although some oils will obviously have better/poorer wear control than others. Mobil Jet Oils (II, 254) have always demonstrated excellent antiwear control. Note, too, that the SOAP process is based on the concept that, if it is possible to identify and quantify wear metal trends in engine lubricants, then it is possible to determine and isolate specific internal engine component problems.

Oil Parameters	Limits
Viscosity (VIS)	+25% TO -10%
Acid Number (TAN)	+2.0 mg KOH/g
Water Content (% H_2O)	1000 PPM
Engine Parameters	
Metals Analysis (SOAP)	+10.0 PPM and trend

Oil Parameters

Viscosity and acid numbers are analyzed to determine the condition of the oil. Upward movement of both these parameters is usually indicative if the oil being exposed to high temperature within the engine oil system, resulting in thermal or oxidative degradation of the oil. There may or may not be carbon deposition within certain areas of the engine oil system depending upon the source of the high temperature. These two parameters are measured and monitored as indicators of high temperature problem areas within the engine. It should be noted that carbon can form on internal parts of the oil system where a "hot spot" exists and not manifest significant change in these two parameters.

The limits used by most engine builders are shown in the above chart. However, it is advised that movement toward those limits during a consistent monitoring program may indicate that a problem is developing in the engine oil system before it exceeds one of the noted limits.

Water in the oil is monitored as a potential contaminate. In ester-based jet oils, large amounts of water combined with heat can result in hydrolysis, resulting in increased acid number.

Water can enter the jet engine oil system both as an accidental contaminate or through condensation because esters are hygroscopic and can absorb water from air.

The main concern is the potential for corrosion due to acid formation.

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Engine Parameters

Analysis of metals is accomplished primarily as a tool to help monitor the condition of the bearings and gears of the jet engine and gearbox. ExxonMobil Aviation Lubricants uses 10 PPM as a gross limit for all metals (except phosphorous) monitored in jet oils. This is based on the general observation over the past 20 years that most engines operating satisfactorily produce wear metal levels close to zero. Most engines that have a wear metal result greater than 10 PPM usually have a wear anomaly. Having said that, the use of an absolute limit in wear metals is not nearly as significant and useful for analyzing problems in the jet engine oil system as the trending upward or downward of a given wear metal, or a group of wear metals.

Trending is important in identifying wear or damage of bearings and gears. These results can be combined with oil filter inspection, vibration results and/or chip detector inspection. The metals monitoring helps to identify slow progressing damage to gears, bearings and spinning bearing races when the wear particles are in the 1-5 micron size.

In analyzing the wear metals results it is important to have a knowledge of the metals used in the engine under construction. The values of the wear metals should be plotted on a graph against engine operating hours. The most common wear metal to show movement is Iron because most bearings have a high percentage. Depending on the bearing metal composition, if a bearing fails, many times the Iron level will increase accompanied by another metal such as Chromium (which may be the second highest compositional metal in the bearing).

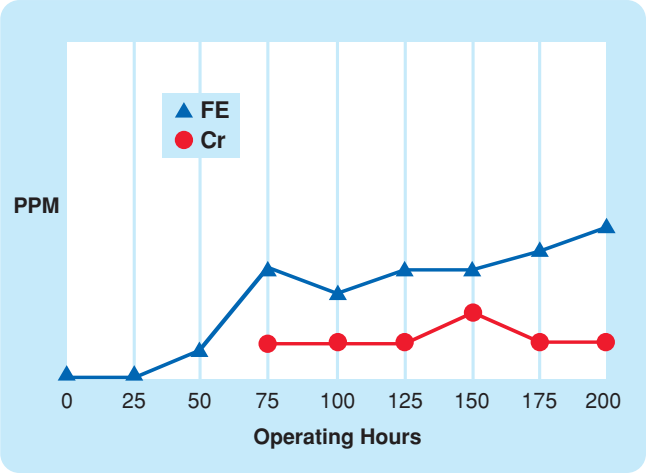
Upward movement of Iron and Titanium and Chrome may indicate a spinning bearing outer race if the engine case is Titanium.

Catastrophic failures of mechanical parts in the oil system usually generate large metal particles which are not easily analyzed by spectrometric oil analysis, but can be analyzed by other means such as ferrography and debris analysis from magnetic chip detectors.

Silicon may indicate either dirt contamination in the oil sample or ingestion of dirt/dust in the engine inlet system. Another source can come from excessive use of Silicone-containing sealants to seal certain parts of the engine/gearbox.

High levels of this type of Silicone can result in oil foaming and possible loss of lubricating qualities and heat transfer capabilities. Inspection of the engine oil filter will many times provide the answer to Silicate (dirt) or Silicone. A foam test on the used oil may be needed if Silicone contamination is suspected.

Below is a typical trend plot of wear metals indicating possible abnormal bearing wear.



Phosphorus

Phosphorus is measured as one of the metals, but it is not an engine wear metal. It is one of the additives used in the oil that provides anti-wear capability. Its value can decrease while it is functioning normally. However, a significant decrease of over 50 percent in the first 100 hours of operation may be cause for concern. This may indicate significant metal-to-metal rubbing of moving elements which could be an early indication of an abnormal bearing or gear failure.

It is important to determine the level of phosphorus in new oil and to trend its value. Occasionally, an increase in measured phosphorus may indicate contamination with other phosphorus containing oil (i.e. phosphate-ester hydraulic fluid) that could have deleterious effects on the oxidation stability of the jet oil.