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Remember, to get the most out of this useful tool, know your source of data and the conditions under which it was generated.

Sediment rating by the ultracentrifuge technique can be a very useful tool in the arsenal of analytical techniques available for the condition monitoring of lubricants. More specifically, sediment rating, in conjunction with other analytical tests (e.g., RPVOT, oxidation by FTIR, water by Karl Fisher titration, etc.) can be used to monitor concentrations of varnish-forming compounds and precursors in turbine oils. A sample of the oil is spun in an ultra-high-speed centrifuge for 30 minutes at room temperature. The oil is then drained from the centrifuge tube, and the residue that sticks to the bottom of the tube is visually compared to a rating chart.

The amount and color of residue remaining in the tube after centrifugation is indicative of the oil's varnish-forming potential. A small spot of medium-to-light brown residue is rated as 1 and a large, dark brown-to-black spot is rated as 8, with whole-number increments in between for varying size and darkness—the higher the rating number, the higher the concentration of varnish precursors.

So far, there is no ASTM or other consensus method for performing sediment rating testing. Still, there is substantial industry information available on some of the key aspects of the method, most notably the specified speed of rotation for the centrifuge and temperature control. Much of the preliminary method development appears to have been performed by Mobil and was formalized into a Mobil Analytical Method [Ref. 1], in 1979. In this method, the criterion for centrifuge speed was established at 17,500 rpm. The method was subsequently revised to include a cautionary note to avoid excessive heating of the samples, which can occur during the centrifuging process. Elsewhere, numerous references to centrifuge speeds of 18,000 and 20,000 rpm have been encountered in literature searches.

Ensuring consistent or repeatable results

The most important factor in centrifuge technology is the Relative Centrifugal Force (RCF), which is related to the standard acceleration due to gravity at the Earth's surface and typically reported in units of g (as in "g-force"). The RCF is related to the speed (rpm) and the radius (cm) of the centrifuge's rotor (the part that actually rotates). Simply specifying the centrifuge rpm rate will not ensure consistent results among different labs, as each centrifuge may have different rotor designs and dimensions. Hence, the samples may be subjected to different RCF values, ultimately producing different sediment rating results.

Ultracentrifuge equipment is designed to generate much higher RCF values than can be obtained with typical centrifuges through much higher rotational velocities (rpm). State-of-the-art ultracentrifuges are capable of spinning at upwards of 150,000 rpm and generating over 1 million g. One of the consequences of such high speeds is the generation of heat caused by friction during the spinning process.

It has been well documented that varnish-forming precursors are sensitive to temperature. That is, the precursors will remain soluble or suspended in the lubricant at elevated temperatures and tend to settle out and form the varnish deposits at lower temperatures. It also has been demonstrated [Ref. 2] that varnish can be resolubilized at elevated temperatures. Thus, it is important to maintain the samples near room temperature to prevent biased results. Ultracentrifuges without proper temperature controls could yield biased low results as the varnish and precursors may dissolve in the lubricant during the centrifuging process. Conversely, over-chilling of the samples could lead to biased high results.

Defining parameter and type of results

Because the sediment rating procedure is not detecting a specific elemental or chemical species—such as calcium by emission spectroscopy or methyl esters by gas chromatography—it is the method itself that defines the parameter and what kind of results are obtained. With method-defined parameters, it is critical for laboratories to adhere to the method and implement it consistently. Without this consistency, results cannot be compared to each other with any reliability. Consistency within a lab is useful, but only for results generated from that lab. Consistency among labs is necessary to be able to compare results generated by multiple labs, particularly, for example, when attempting to evaluate multiple turbine systems in various locations.

Clearly, the turbine industry is in need of a standardized method that specifies the force of the

centrifuge and not just the rotational speed. This will be the only way that results from different labs and different centrifuges can be compared. These days, with so much focus on varnish formation and detection of varnish precursors, it is very important that the analytical test methods be well defined and understood. More consistency is currently needed for the sediment rating methods to allow data comparisons and to bring consensus to this approach. Until then, make sure that you know your source of data and the conditions under which it was generated when comparing or trending sediment rating results. **LMT**

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References

1. "Sediment Rating of Hydraulic and Turbine Oils, Mobil Method 1169", ExxonMobil, adopted 1979 with various updates.
2. "Soluble Varnish – The Final Piece to the Puzzle", Greg Livingstone, et al, published by Noria Corporation, 2008.

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