Understanding Differences in Elemental Analysis Methods

This white paper outlines the different methods of elemental analysis and provides comparative guidance on using these tests.

Elemental analysis is one of the most important tests on an oil analysis report. It determines concentrations of wear metals, contaminants and oil additives in a sample. When reviewing metals on an oil analysis report, it is important to determine what procedure was performed to obtain the results, as the value and accuracy can vary between procedures. It is also important to ensure that the new oil reference was run using the same method of comparison.

Two methods

The two different methods used for elemental analysis are the Inductively Coupled Plasma (ICP) Spectrometer and the Rotating Disk Emission (RDE) Spectrometer, or arc spark. Both instruments use a high-energy source to excite atoms within a sample. The atoms do not want to be in this excited state and as energy is reduced, they give off the energy in the form of light energy. The light energy emitted is specific to each atom. Therefore, the amount of light energy can be converted to a concentration of each element tested.

Five main differences

The main differences between the instruments are the ASTM method, sample preparation, how the sample is vaporized, size limitations, and accuracy, specifically:

ASTM Method – ASTM D6595 is used for the RDE instrument, while the ASTM D4951 and D5185 methods are used for the ICP instrument.

Sample Preparation – The RDE instrument does not need sample dilution/preparation, while the ICP instrument requires sample dilution. There is a trend with oil analysis labs moving to the RDE due to the higher volume of samples and quicker turnaround time.

How The Sample Is Vaporized – The RDE uses a high voltage electrode above a rotating disk to vaporize the sample, while the ICP uses a high-temperature (8500°C+) argon plasma to vaporize the sample.

Size Limitations – The RDE can vaporize particles up to 10 um, while the ICP can vaporize particles up to 5 um due to the sample preparation. If a sample is first run in the ICP, followed by the RDE, certain element concentrations can be higher in the RDE, due to the ICP not being able to handle particles above 5 um. Additional testing would be needed for wear particle analysis of greater than 10 um.

Accuracy – While the ICP has the sample preparation and particle size limitations, the benefit of using this instrument is the accuracy. Some ICP units can get accuracy down to 0.1 ppm, while the RDE would be 1–2 ppm.

Furthermore, two ASTM test methods are used by ICP, the ASTM D4951 and the ASTM D5185.

- The **ASTM D4951** is specific to new oils and is testing for eight additive metals. This method uses a higher dilution concentration and is more accurate than the ASTM D5185 method.
- The **ASTM D5185** method is designed for used oil samples, identifying 22 additive, wear and contamination metals. The eight additive element results can be lower in the D5185 as compared to the D4951 due to the 14 additional metals tested.

Expect some variance in results

We (Phillips 66 technical teams) have found that when using the same method at an outside test lab, we can confirm our plants and suppliers' specifications. When using another described method, the results can vary, sometimes out of a provided range. The ASTM D5185 ICP was consistently up to 10% lower value versus the ASTM D4951 when compared. The RDE procedure has been observed to be consistently lower than both ICP methods. A larger sample set would be needed to see if there is any correlation between the RDE and ICP.

Concentrations of metals on an oil analysis report can vary based on procedure and element tested. It is important to ensure the test method is known, as well as the strengths and weaknesses of each method. It is also important to ensure that there is consistency in methods used for comparing different data (e.g., used oil compared to a new oil reference), and not to mix methods.

Use the same method for used oils and new reference oils

If you are relying on one method at a lab for your used oils, then you should also use the same method at the same lab for the new oil reference for proper comparison. Finally, one elemental analysis report should not be taken as absolute, instead trends in the data should be observed over a historical period while comparing to a new oil reference.

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