The JOAP Method for Oil Condition Monitoring

Using Spectrum OilExpress

Introduction

Many users of heavy machinery must carry out routine analysis of engine, pneumatic and lubrication oils on a regular basis for preventative maintenance. Machinery can include ships, military hardware, mining machinery etc.

The nature of the machinery, the type of engine involved, the environment in which the machinery operates all play a role in the degradation of lubricating oils. Given the value of the machinery and its function, it is clearly essential to continuously monitor the condition of the lubrication, hydraulic and engine systems to avoid expensive repair or replacement of machinery and subsequent down-time.

Several users have developed infrared-based techniques for routine measurement and trending of used oils. This has resulted in the development of different methods, each relating to a distinct type of machinery and operation.

The JOAP Method

The Joint Oil Analysis Program (JOAP) method was developed by the US military, and is used in preference to the reference method. The reference method involves the subtraction of the reference oil spectrum (taken before introduction of the new oil into the machinery) from subsequent used oil spectra.

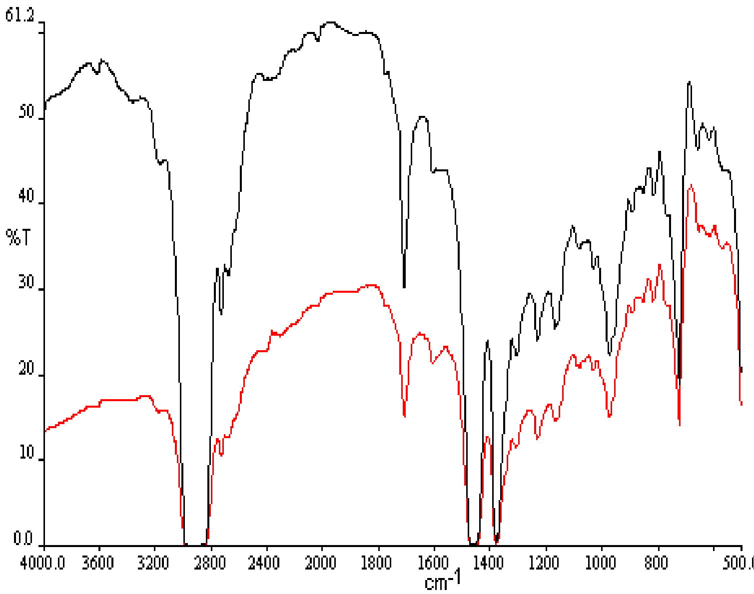
One of the problems associated with the Reference method is that a reference spectrum must be collected and archived for each type of oil in each piece of machinery.

This means that a large reference spectrum database must be archived, and that errors in selecting the relevant reference spectrum could occur.

Also when oils are topped up rather than totally replaced a reference spectrum of the unused reference oil no longer exists.

Example spectra of new and oils that were measured using the reference method are shown in Figure 1.

Figure 1. Spectra of New (black) and Used (red) Oils using the Reference method



The JOAP method differs from the reference method in that it provides absolute values for components of the oil. The method involves the subtraction of an empty cell background from the used oil spectrum. Characteristic regions from the resulting spectrum are used to determine used oil parameters and components (Table 1).

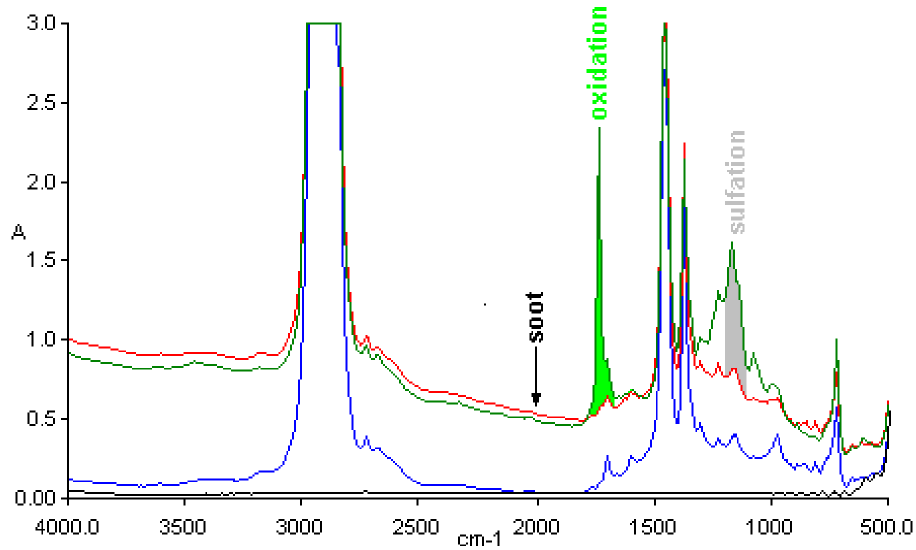
Table 1. Measurement Parameters for the JOAP Method

Parameter	Measurement Area	Baseline point(s)	Reporting
Water	3500-3150 cm-1	Minima 4000-3680 and 2200-1800 cm-1	Report as measured
Soot	2000 cm-1	None	Value * 100
Oxidation	1800-1670 cm-1	Minima 2200-1800 and 650-550 cm-1	Report as measured
Nitration	1650-1600 cm-1	Minima 2200-1800 and 650-550 cm-1	Report as measured
Phosphate-based Antiwear components, e.g. ZDDP	1025-960 cm-1	Minima 2200-1800 and 650-550 cm-1	Report as measured
Gasoline	755-745 cm-1	Minima 780-760 and 750-730 cm-1	Report as measured
Diesel JP-5 & JP-8	815-805	Minima 835-825 and 805-795 cm-1	(value + 2) * 100
Sulfate	1180-1120cm-1	Minima 2200-1800 and 650-550 cm-1	Report as measured
Glycol coolant	1100-1030 cm-1	Minima 1130-1100 and 1030-1010 cm-1	Report as measured

It is critical to collect large amounts of data to obtain a representative picture of typical contamination and degradation levels and their effect on the FTIR spectrum. Typically, a thousand or more samples are analyzed and trend charts created for each parameter for oil condition monitoring.

In Figure 2, example spectra show the empty cell background, a new oil, an oil with excessive soot and an oil with oxidation and sulfate contamination. Acceptance criteria are derived from a study of many results to obtain a series of distribution curves (Figure 3). These are then used in discussion with the machinery supplier and/or

Figure 2 Spectra of Three Oils Obtained using the JOAP method



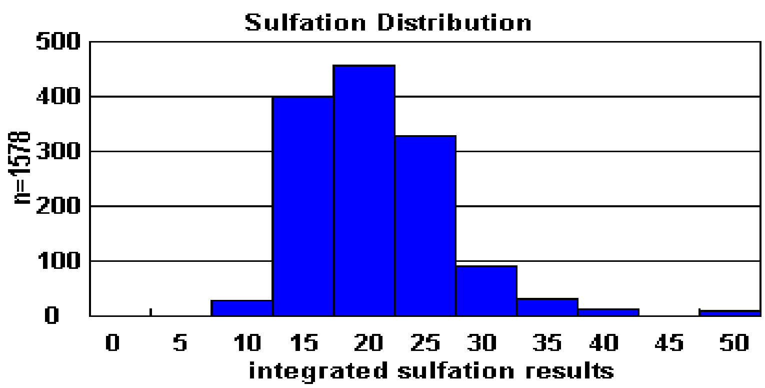
maintenance supplier to set acceptance limits.

Advantages of the transmission cell over HATR

The cell pathlength of 100 µm is ideal for oil analysis. HATR has an effective pathlength of around 20 µm and a low light throughput, reducing sensitivity and increasing scanning time.

The syringe pumps allow rapid and thorough cleaning between samples and provide a very low sample carry-over of less than 0.1%. An HATR crystal requires time-consuming manual cleaning with hydrocarbon solvent, exposing the operator to solvent vapors.

Figure 3 Distribution of results for sulfation for 1578 Diesel Engine Oils



In the OilExpress transmission cell the IR beam passes through the bulk sample, easily detecting particulates like soot, suspended water and glycol. The HATR technique gives low values for soot because it 'sees' only a thin film of sample that is in contact with the crystal.

Finally, the transmission cell operates over a spectral range of 4000 to 500 cm^{-1}, whilst HATR measurements have a cut-off of 650 cm^{-1}.

Conclusion

Spectrum OilExpress provides high quality results for oil condition monitoring for both Reference and JOAP methods.

PerkinElmer Instruments
Headquarters Office
710 Bridgeport Avenue
Shelton, CT 06484-4794 USA
Phone: (800) 762-4000
www.perkinelmer.com