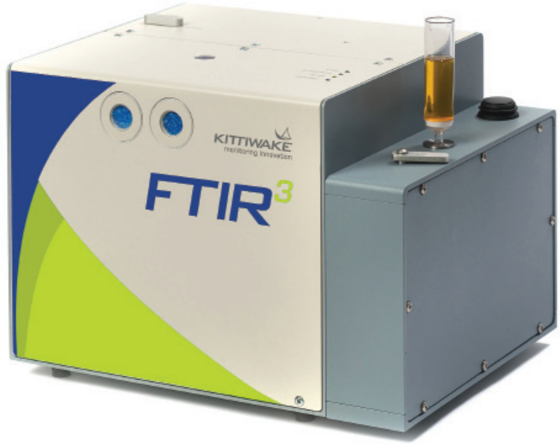
KITTIWAKE
monitoring innovation



FTIR³ Oil Analyser

Fully compliant ASTM oil measurements in the field

The use of on-site, in-service oil analysis is becoming more prevalent as equipment operators gain a greater understanding of the benefits of condition monitoring to protect their major assets.

However, many maintenance staff still send samples to the lab for detailed oil analysis, often involving the use of a lab-based Fourier Transform Infrared (FTIR) spectrometer for detailed spectral analysis. Traditionally lab-based, FTIR machines offer an in-depth understanding of many oil parameters, quickly and without the use of complicated tests and chemical reagents. Kittiwake's *FTIR^3* Oil Analyser now offers all of the advantages of FTIR technology in a compact, field-deployable device, fully compliant to industry standard ASTM (American Society for Testing and Materials) methods and practices[1-6].

Infrared Spectroscopy (IR)

Infrared Spectroscopy (IR) is a form of spectroscopy that measures energy absorption within the infrared region of the electromagnetic spectrum, providing quantitative chemical analysis of the oil's molecular constituents. This is in contrast to, for example, ultra-violet (UV) absorption (or emission) spectroscopy which performs elemental analysis. UV spectroscopy primarily addresses component wear metals and abrasives, whereas IR spectroscopy targets oil degradation, contamination and improper mixing of lubes. Since degraded or contaminated oil is probably the greatest cause of machine wear, IR has become essential in monitoring in-service lubricants. Although manufacturers' precise oil formulations are proprietary and their exact compositions may not be known, many characteristics of the individual constituents of oils are defined by their so-called functional organic groups.

These are sub-groups of atoms within the overall molecular structure that determine the chemical reactivity of the whole molecule. By and large, functional organic groups have unique IR absorption frequencies (energies) enabling almost unambiguous quantification of the parent molecule. In this way it is possible to follow degradation processes via by-product formation or the unwanted accumulation of contaminants such as glycol, water, fuel etc.

FTIR is the predominant IR methodology, providing mathematical calculations at extremely high speeds, enabling rapid analysis with an impressive yield of information. Kittiwake's *FTIR^3* **Oil Analyser** is the first compact, field unit of its type designed to meet ASTM specifications. ASTM compliance assures users that established, trustworthy procedures and operations are employed for best practice and precision.

Kittiwake – FTIR^3 Oil Analyser

The *FTIR^3* **Oil Analyser** is a powerful tool for oil analysis and condition monitoring in the field. It is designed to be extremely user-friendly, while providing a full suite of analytical options. The *FTIR^3* **Oil Analyser** comes pre-loaded with standard ASTM test parameters for the majority of lubrication oil types and requires only minimal intervention from the user.

The *FTIR^3* **Oil Analyser** is comprised of three main components:

- *FTIR^3* spectrometer and sampling system
- Netbook computer and software
- Carrying case

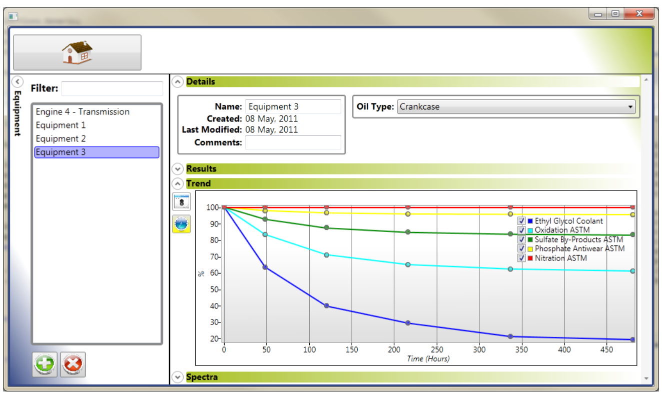
Simple to operate, the unit requires only 3 ml of oil sample to produce accurate, reproducible results in minutes.

Features

- Simple operation
- Field-deployable
- Powerful analysis software included
- Easy flushing of measurement cell

Benefits

- Rapid analysis of multiple parameters
- Small sample size (3 ml)
- Instantly highlights issues with machinery / lubricant



Software

The powerful *FTIR^3* software provided on the netbook is simple to use. It allows users to set up multiple machines and oil types and also define which parameters are measured on each sample. Data is stored on the machine and can either be viewed numerically or in graphical format for trending over time. Custom user-definable alarms can be set for any measured parameters. These can be either a simple pass/fail, or warning levels with various ranges of severity and colour coding, as defined by the user for the specific application. Spectral data can be viewed graphically and compared with new oil spectra.

Oil Parameters

Water in Oil (E2412-10)[2] – Oil and water do not, and really should not, mix. Water can exist in the lubricant in a dissolved or free state and is one of the most common contaminants. Even a small amount of water can be devastating to a lubrication system, with effects such as additive hydrolysis, a destructive, irreversible chemical process that compromises beneficial effects, rust and corrosion.

Anti-oxidant depletion (E2412-10)[2] – Anti-oxidant packages are added to oils to reduce the speed of the oxidation process. Monitoring of this can be used proactively in order to determine proper oil drain periods and to extend oil change intervals through timely antioxidant additive replenishments.

Glycol contamination (E2412-10)[2] – Glycol can enter lubrication systems, usually from cooling system egress to the oil sump. It can interact with the oil to form a tacky resinous substance capable of sticking piston rings and, in severe cases, resulting in bearing and piston seizures.

Fuel Soot (E2412-10)[2] – Diesel engines routinely generate combustion soot (fine, sub-micron carbon particles), due to incomplete fuel combustion cycles, rendering an oil virtually black. High amounts, however, suggest possible issues with injector nozzles, valve timing, or worn rings and liners. High soot readings also signal the need to change oil and filters. Fuel soot doesn't possess a 'functional group', but the FTIR process can still accurately assess fuel soot quantities by monitoring its degree of influence on light scattering within the IR spectrum, based on a principle known as Tyndall Scattering.

Phosphate anti-wear additive depletion (D7412-09)[3] – Anti-wear additives (commonly in the form of zinc-phosphorus compounds) work by forming a chemical barrier activated by frictional heat and are commonly used in lubricants to prevent machinery wear. They initially decompose and form a protective film by binding to metal and so a decrease in the level of phosphate anti-wear additive relative to that in the new oil is expected during normal machinery operation. However, significant depletion may occur due to oxidation and hydrolysis can occur when the lubricant is subjected to high temperatures and high moisture levels. Trending of phosphate anti-wear additives is a useful indicator of the lubricant's remaining in-service life.

Oxidation (D7414-09)[4] – As oil becomes hot in the presence of oxygen (air) it oxidizes and tends to become more viscous. The oil's chemistry is irreversibly altered in a negative way reducing its lubricating properties and becoming a precursor to varnish formation with subsequent deposit build-up. Though good additive chemistry may forestall oxidation, all mineral-based oils will oxidize over time even in normal service. [Synthetic and partial-synthetic lubricants exhibit a higher resistance to oxidation, an obvious benefit of such products].

Nitration (D7624-10)[5] – Nitration is similar to oxidation, but involves nitrogen instead of oxygen. While not as severe as oxidation, excessive nitration can still degrade lubricity. It is most prevalent in natural gas combustion operations, such as pipeline gas engines and propane or butane fueled forklift engines. Issues with combustion timing that is too lean (a fuel conservation routine) are often manifested by excessive nitration.

Sulphate-by-products (D7415-09)[6] – Sulphur is present in different chemical forms in most diesel fuels and monitoring sulphate by-products is a very good indication of the amount of attack on the lubricant's alkaline reserve. BN (Base Number) and AN (Acid Number) can be used for corroboration and correlation purposes.

Applications

TEST	MACHINE TYPE (Traditional Method)	Diesel Engine	Gas Engine/ Compressor (Natural Gas, etc.)	Compressor (Air, etc.)	Gearset	Hydraulic
Oxidation	(Total) Acid Number	Timing issues Excessive lube time Low oil level/starvation Aeration High contact wear	Timing issues Excessive lube time Low oil level/starvation Aeration High contact wear	Excessive lube time Low oil level/starvation Aeration High contact wear	Excessive lube time Low oil level/starvation High contact wear Aeration Overloading	Excessive lube time Aeration High contact wear Overloading
Nitration	None	Timing issues Excessive lube time	Timing issues Excessive lube time	N/A	N/A	N/A
Sulphate by-products	(Total) Base Number	Alkaline reserve depletion Excessive fuel sulphur	N/A	N/A	N/A	N/A
Fuel Soot	Thermogravimetry	Timing issues Excessive lube time Ring/liner wear	N/A	N/A	N/A	N/A
Oil Mixing	None	All Oils	All Oils	All Oils	All Oils	All Oils
Additive Depletion	None	Requires new lube referencing	Requires new lube referencing	Requires new lube referencing	Requires new lube referencing	Requires new lube referencing
Water	Karl Fischer or Crackle Test	Very significant coolant leak or invalid (taken cold) sample	Issues with handling/ storage, environment, coolant or sampling	Issues with handling/ storage, breathers, environment or sampling	Issues with handling/ storage, breathers, environment or sampling	Issues with handling/ storage, breathers, environment or sampling
Glycol contamination	Colorimetry, Gas Chromatography	Coolant leaks (oil cooler, injector, gasket)	Coolant leaks if applicable	N/A	N/A	N/A
Phosphate Anti-wear	Elemental Analysis (vague indication)	Verify sufficient active additive is present	Verify sufficient active additive is present	Verify sufficient active additive is present	Verify sufficient active additive is present	Verify sufficient active additive is present

1 ASTM - D7418-07 Standard Practice for Set-Up and Operation of Fourier Transform Infrared (FTIR) Spectrometers for In-Service Oil Condition Monitoring.
2 ASTM - E2412-10 Standard Practice for Condition Monitoring of in-service Lubricants by Trend Analysis Using Fourier Transform Infrared (FT-IR) Spectrometry.
3 ASTM - D7412-09 Standard Test Method for Condition Monitoring of Phosphate Anti-wear Additives in In-Service Petroleum and Hydrocarbon Based Lubricants by Trend Analysis Using Fourier Transform Infrared (FTIR) Spectrometry.
4 ASTM - D7414-09 Standard Test Method for Condition Monitoring of Oxidation in In-Service Petroleum and Hydrocarbon Based Lubricants by Trend Analysis Using Fourier Transform Infrared (FTIR) Spectrometry.
5 ASTM - D7624-10 Standard Test Method for Condition Monitoring of Nitration in In-Service Petroleum and Hydrocarbon Based Lubricants by Trend Analysis Using Fourier Transform Infrared (FTIR) Spectrometry.
6 ASTM - D7415-09 Standard Test Method for Condition Monitoring of Sulphate By-Products in In-Service Petroleum and Hydrocarbon Based Lubricants by Trend Analysis Using Fourier Transform Infrared (FTIR) Spectrometry.

Kittiwake – *FTIR³* Oil Analyser

The *FTIR³* Oil Analyser is configured to comply with ASTM-D7418[1] Standard Practice and the included software comes pre-loaded with the complete range of ASTM approved methods used for the condition monitoring of in-service lubricants, including:

- Sulphate by-products
- Oxidation
- Nitration
- Phosphate Anti-wear

In addition, the following parameters are also calculated using ASTM defined test practices[2]:

- Soot
- Water
- Antioxidant depletion
- Glycol contamination

Spectral range	5000 - 600 cm^{-1}
Resolution	2 cm^{-1}
Interferometer	Pendulous type, self-compensating for tilt & shear
Beam splitter	ZnSe
Source	Ceramic, air cooled
Data acquisition	18 bit ADC
Dimensions	27 x 21 x 19 cm
Weight	10 kg (excluding case)
Power	12 VDC, 30 W (PSU included)
Temperature	15 °C to 30 °C
Humidity	Below 65%, non-condensing

As further methods are agreed upon within the ASTM, these can be easily added to the in-built library within the *FTIR³*

Ordering Information

1 x FG-K19000-KW *FTIR³* Oil Analyser with case, netbook and accessories.

For more information regarding the ***FTIR³* Oil Analyser**, please contact your local Kittiwake office

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