Spectro Scientific
Confidence in knowing

WHITE PAPER

OVERVIEW OF FLUIDSCAN® HANDHELD INFRARED OIL ANALYZER

Spectro Scientific

Figure 1: FluidScan handheld fluid condition monitor.

Introduction

Oil analysis is a critical predictive maintenance technology. Service or reliability professionals, whether managing a truck or locomotive fleet, a marine vessel or fixed assets in an industrial plant, rely on oil analysis information to schedule maintenance actions. The need to continuously improve uptime and reduce maintenance costs demands in situ oil analysis results for better decision-making using oil analysis data as well as other predictive maintenance technologies.

However, performing on-site oil analysis is difficult due to the following challenges:

- lack of in-house expertise
- insufficient oil analysis instrumentation
- logistics of handling hazardous chemicals and waste recycling

The FluidScan® device (Figure 1), was designed to address the above mentioned challenges faced by reliability professionals. It is a handheld infrared oil analyzer that delivers fluid condition assessment based on ASTM International and JOAP (Joint Oil Analysis Program) standard practices. It protects machinery by determining when a lubricant needs to be changed due to excessive contamination, degradation or fluid mix ups, considered the most comon causes of oil changes. FluidScan detects lubricant degradation and contamination by other fluids (water, glycol, incorrect lubricant) at the point of use by measuring key oil condition parameters in both synthetic and petroleum-based lubricants and fluids.

The FluidScan analyzes lubricants and fluids using infrared spectroscopy, a technique that has found wide acceptance as a primary test for contamination and degradation. The device performs, displays and stores the analyses with the same accuracy as laboratory instruments, but does so on-site in a handheld version. The analysis information stored on the device's database can be synchronized with the FluidScan Manager software, a powerful database analysis package which runs on a personal computer and archives and trends data and generates fluid condition reports.

The FluidScan lubricant condition monitor is applicable to any mechanical system where unexpected downtime, as a result of lubricant degradation and/or contamination, is unacceptable. It enables operators of power generation and mining equipment, marine vessels, trucks, wind turbines, military vehicles and aircraft, heavy construction equipment,

or any large industrial system, to establish predictive maintenance programs based on oil condition rather than on a pre-set time or distance schedule.

The FluidScan provides immediate on-site analysis of lubricant properties, and accurately warns the user when it is time to change the lubricant due to contamination or degradation. The primary benefits of real-time, on-site analysis include:

- Extended oil change intervals
- No delay in waiting for laboratory analysis results
- Reduced operational and maintenance costs
- Reduction of unscheduled maintenance outages
- Prevention of catastrophic failures

Patented Optics and Flip Top Cell

The FluidScan monitor is a self-contained handheld analyzer that delivers instant fluid condition assessment to the user. It eliminates sample preparation and time-consuming cleanup using a patented flip top sampling cell for easy and rapid on-site analysis as shown in Figure 2. At the core of the FluidScan is a patented, midinfrared spectrometer with no moving parts. The spectrometer collects the infrared light transmitted through the fluid in the flip top cell into a waveguide as illustrated in Figure 3. The waveguide then carries the light to a prism-like diffraction grating that reflects the light into a high-performance array detector which registers the infrared spectrum of the fluid. The waveguide completely contains the infrared signal, minimizing any atmospheric interference and maximizing the amount of light within the spectrometer. In this way, the FluidScan maximizes optical throughput and spectral resolution in a palm-sized device. Consequently, it provides more than adequate spectral range, resolution and signal-to-noise ratio for the rapid analysis of in-service lubricants. This unique technology has been optimized for low power consumption, enabling the production of a rugged, highly accurate miniature device that operates on Li-Ion batteries for up to eight hours.

Figure 2: Patented flip top cell eliminates the need for solvents to clean.

Key infrared signatures of fluid condition, established by industry norms and ASTM condition monitoring standards, are used to obtain fluid status in real time. The user loads a sample into the flip top cell, enters sample information, and initiates an analysis using FluidScan's intuitive user interface and navigation pad. Status and supporting fluid condition parameters are then determined and displayed to the user and can be stored for trending and exporting to a central database. The information stored on the FluidScan device resides in a SQL database and can be synchronized and downloaded to a PC using the FluidScan Manager database software. This software provides data logging, trending, warning and alarm condition alerts. The FluidScan can operate without ever needing a PC, but the FluidScan Manager desktop application makes data entry and reporting easier.

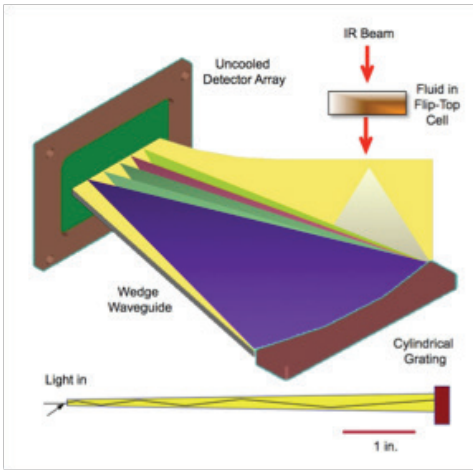

Figure 3: Patented wedged optical design

Multivariate Calibration and Data Correlation to Laboratory Results

Most oil analysis users will compare FluidScan results to those output from a traditional off-site laboratory. Most laboratories report lubricant condition parameters using a combination of benchtop FTIR (Fourier Transform Infrared Spectroscopy) spectrometers and wet chemistry titrators.

One of the advantages of the FluidScan over laboratory FTIR is its ability to report absolute quantitative results for critical properties such as TAN and water contaminations for industrial lubricants or TBN, water, glycol, and soot for engine oils. It is only possible to obtain good absolute quantitative results through infrared spectroscopy by referencing both the correct fluid type and a calibration for that type of fluid property, as is provided with the FluidScan.

The FluidScan classifies fluids into groups called families based on their chemical makeup, usage and spectral signature. The spectrum of all fluids in each family changes in a similar way with a given amount of degradation or contamination. Family-specific algorithms are assigned that accurately quantify these amounts. These algorithms yield quantitative results for the most critical properties for the most common oil types. Multivariate calibrations are applied so that quantitative readings can be obtained even with complex contaminated samples. Our research, development and applications group has produced an extensive library of spectra from a large database of commonly used lubricants. Chemometric techniques are used to automatically subtract the presence of interferants in a given calibration. The TAN, TBN and water are calibrated directly to wet chemistry titration readings. Soot is calibrated to soot percentages determined by thermo-gravimetric analysis. Glycol and incorrect fluid percentages are calibrated to samples prepared with known concentrations of glycol and incompatible fluids. Table 1 summarizes key FluidScan properties and the ASTM protocols to which they correlate as a result of this calibration process.

FLUIDSCAN PROPERTY	REFERENCE LAB METHOD
AW Additives	ASTM D7412/E2412 (FTIR)
Oxidation	ASTM D7414/E2412 (FTIR)
Sulfation	ASTM D7415/E2412 (FTIR)
Nitration	ASTM D7624 (FTIR)
Glycol	ASTM E1655 and E2412
Soot	ASTM D5967 (Thermo-Gravimetric Analysis)
TBN	ASTM D4739 (Titration)
TAN	ASTM D664 (Titration)
Water	ASTM D6304 (Karl Fischer Titration)

Table 1. Key FluidScan parameters and corresponding ASTM protocols

To apply the correct algorithms to a particular sample, the spectrum of a new oil of the same type as the in-service oil to be tested, is measured on the FluidScan. The new oil is analyzed with spectral matching software and the best possible match is made of the unknown sample with lubricants already in the FluidScan's database.The algorithms associated with that lubricant can then be applied to samples of that oil at any stage in its service life to produce quantitative results. Figure 4 shows an example of data correlation between the laboratory and FluidScan for TAN of in-service turbine oils.

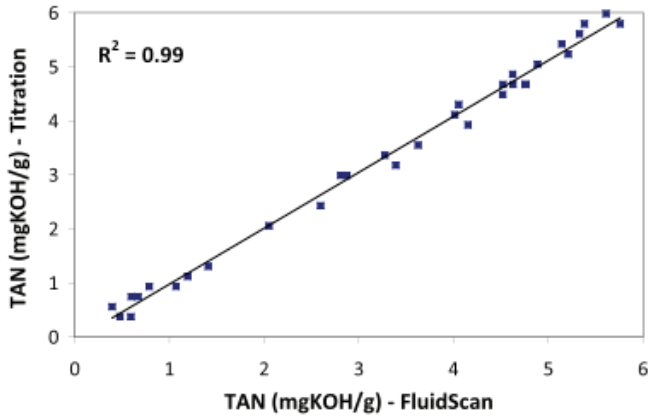

Figure 4: In-service turbine oils Total Acid Number chemical titration vs. FluidScan

The FluidScan has been used extensively to measure properties for petroleum- based engine oils (TBN, water, soot, oxidation, nitration, sulfation, glycol, and additive depletion), synthetic ester turbine oils (TAN, water, and antioxidant depletion) and hydraulic fluids (TAN, water and oxidation), etc. The other families include a wide range of petroleum and synthetic gear oils, transmission fluids, marine diesel fluids and phosphate ester oils. The database also includes parameters specifically for biodiesel feedstock, finished product and diesel/biodiesel blends. Table 2 lists parameters for some of the common lubricants in FluidScan.

Alarm Limits and Reference Oil Library

In addition to reporting quantitative values for these properties, the FluidScan provides the results in an easy to understand "go", "no go" format. This is done by using absolute warning and alarm values for each property. The report uses a simple green, yellow and red system to indicate fluid within limits, near alarm state and over alarm limits (Figure 5).

	Engine	Hydraulic	Synthetic Gas Turbine	Compressor/ transmission	Gear/Turbine
Water (ppm)		✓	✓	✓	✓
Oxidation (abs/mm2)	✓	✓		✓	✓
TAN (mg KOH/g)		✓	✓	✓	✓
TBN (mg KOH/g)	✓				
Anti-wear Additive (%)	✓				
Nitration (abs/mm2)	✓				
Sulfation (abs/mm2)	✓				
Soot (%)	✓				
Glycol (%)	✓				
Anti-Oxidant Additive (%)			✓		

Table 2: FluidScan parameter settings by oil type

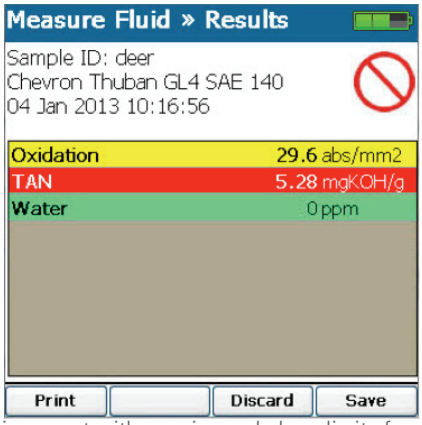

Figure 5: Go/No-go results based on alarm limits

The system is pre-set with warning and alarm limits for properties associated with each of the fluids in the database. These default alarms are based on industry best practices. All warning and alarm limits are completely customizable. Every limit can be set with an upper and/or lower bound. They can be modified to comply with equipment manufacturer's recommendations or particular applications. The FluidScan software has a system that allows the user to define pieces of equipment as assets in the device's onboard SQL database. Each asset can be defined with its own set of property limits. Sample measurements are then saved and associated with that piece of equipment.

FluidScan comes with a built in reference oil library optimized for automotive, marine, railway, military and industrial applications. The total library includes over 450 mineral and synthetic lubricants of over 60 brands and growing. Each lubricant comes with starting values corresponding to laboratory measurements or data sheets. A key feature of FluidScan is the Validate Fluid function that matches the spectrum of any clean sample with those in the reference library. Using this function, one can easily identify an incorrect lubricant before it is added into the system.

In summary, the FluidScan's combination of patented IR technology, sampling flip top cell, unique calibration algorithms and large reference library with built-in alarm limits puts the power of FTIR, Karl Fischer Titration and TAN/TBN Titration into the hands of reliability engineers. This is accomplished without the need for lengthy measurement processes, expensive chemicals or a trained chemist to run the tests. It simplifies on-site oil analysis and enables reliability engineers to perform oil analysis as they do vibration analysis and thermal imaging. By carrying the FluidScan with them on a maintenance route, information from these three key technologies can then be easily integrated for better predictive maintenance decisions.

Spectro Scientific | One Executive Drive, Suite 101, Chelmsford, MA 01824-2563 | 978-431-1120
sales@spectrosci.com | sales@spectroinc.com An ISO 9001:2008 company