TECHNOLOGY

# The History of Oil Analysis

## Why We Have Sensors

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Onboard sensor technology and its usage is expanding every day. These types of sensors represent a dynamic, long-term paradigm shift in the way oil is and will be analyzed. Tracing the history of oil analysis will help explain how this came about and, perhaps, where it might lead.

### In the Beginning

The first serious inspection efforts were made in laboratories far away, for the most part, from the component where the sample was taken. As oil analysis became increasingly more recognized, patience was not a virtue, and those relying on the service wanted more expeditious processing. Sending samples cross-country and waiting for a mailed report could be exasperating. In the 1980s, regional laboratories began to thrive and larger oil analysis firms opened branches in an effort to cover a wider geography via improved turnaround time.

Facsimile machines helped in some instances, and the web, of course, would eventually become the standard for returning reports. Nowadays, a mailed report, other than for confirmation purposes, is antiquated.

Wear metals monitoring came about in the 1960s to complement lube quality and contamination monitoring. This approach was begun in earnest by U.S. commercial railroads in the late 1940s, but was mainly confined to this singular application for more than a decade. This was because analyses were performed by old-fashioned bench testing by chemists, one metal at a time.

Then, Walter Baird invented the direct reading emission spectrometer, capable of analyzing dozens of elements in one pass, and requiring no special talent in chemistry to operate. This was the major paradigm shift in oil analysis, which had suddenly become "machine analysis."

Figure 2. Moisture Sensor (Humidity/Temperature)

### Status Quo, 1970

Through the 1970s, the redefinition of oil analysis involved wear metals, viscosity, contamination and degradation testing of the lubricant. This suite of tests was reasonably complete and provided good information and value, but it lacked a major need, large (> 5 micrometers) particle inspections.

### Large Particle Inspection

The technology of the 1980s brought about routine particle sizing and counting, directly addressing the need to detect and count particles from five to 100 micrometers. Particle counters don't distinguish between particulate nature, simply sorting, sizing and counting; but parallel techniques like analytical ferrography allowed more comprehensive inspection, often

Figure 1. Oil Condition (Dielectric) Sensor

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including at least basic metallurgy. More exotic testing such as scanning electron microscopy could occasionally be included, but today the modern oil analysis suite is rather comprehensive and includes wear metals, contamination and degradation tests, general particulate analysis and wear particulate analysis.

## Enter the Sensors

Systematic improvement and weight and size reductions in the instrumentation for analysis has occurred over time, and therein lays the path and connection to sensors. The majority of used oil analysis is now performed using computer-governed instrumentation. Sensors effectively represent miniaturization of bench-top instrumentation, but with little or no moving parts. Wet chemistry methods once yielded to electromechanical, then graduated to computer-driven bench instrumentation, and now this instrumentation is under siege from further miniaturization in the form of a sensor.

Like the first analytical instruments used for oil analysis, sensors initially exhibited problems with sensitivity, accuracy, repeatability and dependability. The first popular sensor was a small, portable dielectric constant device, roughly modeled after larger units used in transformer oil testing. Several manufacturers ventured into this market with handheld devices, but none delivered a product that was discriminating enough to be highly useful (as evaluated by several oil testing labs).

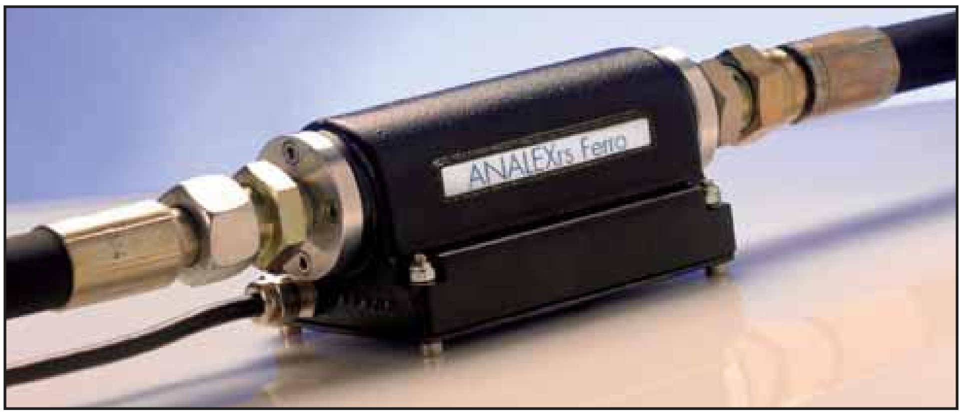


Figure 3. Particle Content Sensor


Figure 4. Ferrous Debris Sensor

## Today

The most populous onboard sensor is currently churning out dielectric strength readings (Figure 1), but in a more sophisticated fashion, such that small differences can be observed and correlated to oil property changes, or problems. Additive depletion, water, fuel, metals, nonmetallic contaminants, or a blend of such occurrences will alter the dielectric constant of the oil, but cannot be differentiated just from the sensor's output. Clearly, the next step would be to send a sample to the lab; but the sensor will have initiated a warning indicating significant change.

Oil monitoring sensors have further evolved to be more specific, addressing viscosity, water (Figure 2), particle counting (Figure 3) and ferrous debris (Figure 4), among other more singular properties. It is perhaps a matter of time until complex differentiation of particles as to metallurgy, shape and quantity is feasible via onboard sensor, as technology continues to drive capabilities up and costs down. If and when this occurs, are used oil analysis laboratories out of business? Perhaps, but such an occurrence is not likely to happen any time soon but, rather, over decades. First there is the matter of technology development (the R&D), then the cost to bring products to the marketplace. There will also be the issue of retrofitting, which may not prove economical for older equipment in life cycle cost assessments.

Sophisticated systems such as the composite sensor suite (Figure 5) are cost-justifiable for a few component types. Large installations, such as ocean-going vessel engines, or gas transmission engines/compressors are typical candidates for this type of monitoring. In the case of large, expensive piston engines, it may be justifiable to monitor each cylinder for ferrous debris; thus, a two-cycle 10-cylinder engine would utilize 10 ferrous debris monitors.

It seems reasonable to expect that sensor development and proliferation will replace numbers of the tests now performed in laboratories, causing yet another paradigm shift in which the labs provide more sophisticated testing to supplement sensor observations.

## The Future (Sorting Things Out)

Once infrared analysis (FTIR) becomes sufficiently miniaturized and cost-effective (and that development is on the horizon), a host of oil property inspections will potentially become the domain of sensors. On that assumption, and with other developments now being perfected, the following substitutions for laboratory testing can be expected in the not too distant future:

- Water (initially replacing cursory inspections, later, Karl Fischer)
- Carbonaceous materials (soot)
- Oxidation
- Nitration
- Sulfation
- Contamination of synthetic oils with mineral oils
- Certain types of additive depletion
- Viscosity
- Fuel dilution
- Certain types of seal material
- Ferrous debris (particle quantifier, direct reading ferrography, etc.)
- Particle count

Figure 5. On-line Sensor Suite - Moisture, OIl Condtion and Ferrous Debris

## What Will be Left for Labs?

- Some applications are not suitable for sensors (systems without circulating pumps such as gear boxes may not apply).
- Spectrometric metals – a tough challenge for sensors near-term.
- Microscopy (analytical ferrography, SEM) – competing, however, with onsite filter patch inspections.
- New discoveries for insight into machinery via oil analysis, something laboratories and instrument manufacturers have been doing all along.

This prospect is not immediately bleak for labs because the evolution (paradigm shift) figures to be a plodding process by today's standards. Still, some unexpected development may accelerate this shift faster than anticipated, and the above scenario could transpire in a matter of a few years.

Leaving the above scenario to its course, how might sensors alter sampling habits in the meantime, and over the course of this evolution? This is a far more interesting question and proposition, because human nature will play a major role in its answer. Many people use oil changes to cure problems, thus if the sensor result indicates a problem that is not immediately discernible, will a sample be pulled, will the oil simply be changed, or will the result be ignored?

All three responses will co-exist in the maintenance world. **POA**