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Comparing TGA, FTIR and Fixed Filter Infrared Analyzers for Measuring Soot Levels in In-Service Lubricants

Measuring soot in diesel engine oil has become more important as soot levels get higher due to exhaust gas recirculation. As soot is one of the key indicators for the condition of the oil, diesel engine maintenance programs performing regular soot checks can realize cost savings by extending drain periods and reducing used oil disposal.

TGA (Thermal Gravimetric Analysis) is the traditional method for soot analysis but it is a time consuming, labor intensive method. Many oil testing laboratories have opted for more rapid infrared (IR) analysis. As shown in the Table 1, IR correlates well with TGA.

Engine Hours	TGA	IR
0	0.13	0.1
50	1.76	1.7
100	3.13	3.2
150	4.48	4.5
175	5.16	5.0
200	5.80	5.8
225	6.38	6.1
0	0.09	0.0
24	0.83	0.8
48	1.40	1.4
72	1.98	1.9
96	2.52	2.5
120	3.05	3.0
144	3.58	3.5

Table 1: TGA vs IR

While most people think of FTIR Spectrometers for infrared measurements, compact fixed filter infrared analyzers for routine tests are less expensive and easier to use making them more amenable to repetitive analyses. The TGA/IR comparison in Table 1 was done on a single wavelength fixed filter analyzer, the InfraCal Soot Meter (see photo). Table 2 shows comparative data for an FTIR and fixed filter IR. The comparisons show that both FTIR and filter based IR analyzers can replace TGA for measuring soot levels.

Sample	FT-IR	Soot Meter
A1	1.46	1.4
B1	1.59	1.6
B2	1.82	1.8
B3	1.94	1.9
B4	2.56	2.5
A2	2.74	2.6
B5	2.68	2.7
B6	2.81	2.8
B7	2.82	2.6

Table 2: FTIR vs InfraCal Soot Meter

Having access to a full spectrum gives an FTIR Spectrometer the capability to measure a number of different oil parameters in addition to soot. For testing labs that can perform upwards of 1000 soot tests a week or for a remote mobile lab, it is advantageous to reserve the more expensive equipment for specialized tests and have a non-technical operator use a single wavelength analyzer for the repetitive soot measurements.



InfraCal Soot Meter

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Confidence in knowing

The InfraCal single wavelength infrared analyzer, offers several advantages over an FTIR for soot in diesel engine oil analysis

1. **Measure up to 12%-15% soot without dilution:** An FTIR with a transmission sampling stage will measure a maximum soot concentration of 5%. Samples above the saturation point must be diluted to be within that measurement range.
2. **Small foot print:** Whether the location is an on-site mobile lab or a crowded testing lab, the instrument's 6" x 6" footprint is a space saver.
3. **Rugged construction:** With no moving parts and a battery pack option, filter based IR analyzers are ideal for field based operations such as heavy duty off road vehicles at construction or mining sites as well as high volumes of samples in a laboratory.
4. **Compatible with ASTM D7686 Test Method:** *Standard Test Method for Field-Based Condition Monitoring of Soot in In-Service Lubricants Using a Fixed-Filter Infrared (IR) Instrument*
5. **No cells to clean or cleaning solvents required:** Samples are applied directly to a scratch resistant cubic zirconia ATR (attenuated total reflection) surface and wiped off with a paper towel. FTIR transmission cells require careful cleaning with solvents.

With the recent increase in biodiesel use, concerns have arisen over whether biodiesel fuel dilution would bias the soot measurement. The results in Table 3 from a recent study for the ASTM D7686 Method found no interference from either diesel or biodiesel fuel dilution using IR analysis.

Intial Soot Concentration	Biodiesel Concentration	Diesel Concentration	Soot concentration with dilution	InfraCal Soot Meter
7.7%	0.0%	0.0%	7.7%	7.8%
7.7%	5.0%	0.0%	7.4%	7.3%
7.7%	15.0%	0.0%	6.6%	6.7%
7.7%	0.0%	5.0%	7.4%	7.3%
7.7%	0.0%	15.0%	6.6%	6.6%

Table 3: ASTM D7686 Fuel Dilution Study

Infrared analysis is a significantly easier and quicker way to measure soot levels in used oil than TGA. Filter based infrared analyzers, such as the InfraCal Soot Meter, are a less expensive way to get a simple, field capable spectroscopic check of the operational condition of the lubricating oil in all types of diesel engines. The analysis takes less than 30 seconds and be handled by individuals with little or no infrared spectroscopy knowledge.

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