

ACCURATE FUEL DILUTION IN THE FIELD USING THE Q6000 FDM: A COMPARISON TO GAS CHROMATOGRAPHY

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Synopsis

The most widely accepted direct method for analyzing fuel dilution in lubricants is Gas Chromatography (GC) according to ASTM methods D3524, D3525, and more recently, D7593.¹⁻³ Other conventional measurement techniques for fuel dilution are indirect measurements which include viscosity, flash point testing and FT-IR spectroscopy.

However, the need for a portable, on-site fuel dilution measurement exists in the marketplace. Obtaining results within a matter of minutes could mean the difference between a serious engine failure or a minor maintenance issue. This application data included below reports on the results of a comparison between field-based fuel dilution using the Q6000 FDM and the traditional gas chromatography technique.

Introduction

Fuel contamination in a lubricant is one of the most important lubricant failure modes in internal combustion engines. The presence of fuel reduces the oil viscosity which decreases the load carrying ability of the lubricant. Unchecked fuel dilution issues in a lubricant can lead to severe wear to bearings, gears, and pistons. Other fuel dilution failure mechanisms include lubricant breakdown and seizure, increased oil oxidation and sludge deposits, as well as explosion due to the presence of light-end, highly volatile hydrocarbons.

The most widely accepted direct methods for analyzing fuel dilution in lubricants is by Gas Chromatography (GC) according to ASTM methods D3524, D3525, and more recently, D7593.¹⁻³ These methods provide highly accurate results and are designed for high volume labs due to the fact that they are expensive and require experienced technicians. Also, GC analysis can be very time consuming to get the best result. Many commercial laboratories have modified the ASTM methods in favor of a faster and more robust method developed by a leading GC manufacturer.⁴

Other conventional measurement techniques for fuel dilution are indirect measurements which include viscosity, flash point testing, and FT-IR spectroscopy. Viscosity tests are routinely performed on a lubricant anyway, but a change in the viscosity does not exclusively conclude a fuel dilution problem. Flash point testing requires correlation tables generated from known samples in order to output fuel dilution in a useful unit, such as %. FT-IR spectroscopy cannot easily distinguish between fuel hydrocarbons and those present in the base oil making it difficult to achieve accurate results.

There is a need for a portable, on-site fuel dilution measurement. Obtaining results within a matter of minutes could mean the difference between a serious engine failure or a minor maintenance issue. The new Q6000 portable Fuel Dilution Meter (FDM) has been developed to meet this need.

Portable Fuel Dilution Measurement by the Q6000 FDM

The Q6000 FDM is a portable, battery operated fuel dilution meter that determines the concentration of fuel dilution present in an oil sample within a matter of minutes (Figure 1). The Q6000 FDM uses a unique patent pending fang design to pierce the cap of a disposable sample vial and draws in the headspace from the vial. The headspace flows over a SAW (Surface Acoustic Wave) sensor which reacts specifically to the presence of fuel vapor with a detection range of 0 – 15%



Figure 1: Q6000 Fuel Dilution Meter

As per Henry's law, the amount of fuel diluted in the oil is directly proportional to the vapor in the headspace of a closed sample vessel at equilibrium (Figure 2).

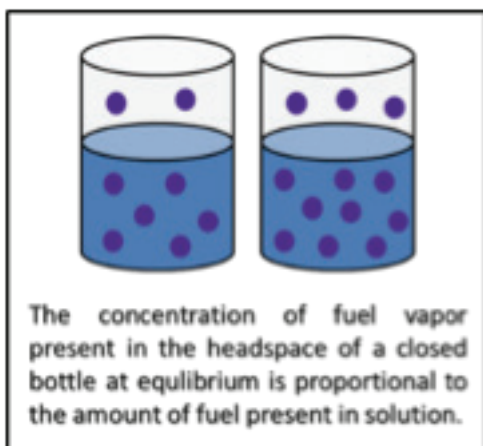


Figure 2: Henry's law as it applies to fuel dilution.

Comparative Study

A comparative study between the GC reference method and the Q6000 FDM was performed. Three sets of typical lubricant calibration and test samples containing various amounts of diesel fuel dilution were obtained (Table 1). The calibration samples were used to calibrate the Q6000 FDM prior to analysis of the test samples. The samples were also sent to an ISO 17025 accredited commercial laboratory for comparative analysis to GC by modified ASTM D3524.^{1,4} The instrument used was a PE Clarus 500 gas chromatograph using a 7 point calibration curve (correlation coefficient of >0.999) created with mixtures of 15W-40 engine oil and #2 diesel fuel.

SAMPLE	TYPE	N
A0	Calibration	New Mobil Delvac 1 ESP 5W-40 oil, no soot present, 5% diesel fuel dilution
A1	Test	Used Mobil Delvac 1 ESP 5W-40 oil, no soot present, unknown diesel fuel dilution
A2	Test	Used Mobil Delvac 1 ESP 5W-40 oil, significant soot present, unknown diesel fuel dilution
A3	Test	Used Mobil Delvac 1 ESP 5W-40 oil, significant soot present, unknown diesel fuel dilution
B0	Calibration	New Esso Racing 20W-50 oil, no soot present, 5% diesel fuel present
B1	Test	Used Esso Racing 20W-50 oil, no soot present, diesel added to 13.4% fuel dilution

Table 1: Diesel fuel dilution calibration standards and test samples used in the comparative study between the Q6000 FDM and GC methods.

The known samples A0 and B0 were used as calibration standards (prepared to 5.0%) for the Q6000 FDM. Calibration of the Q6000 FDM can be performed with any known sample within the detection range. To run the sample analysis, 0.5 mL of sample was dispensed using a graduated disposable pipette onto the felt disc inside the FDM sample vial. Samples were prepared in triplicate and analyzed consecutively (Figure 3).



Up to 5 samples can be prepared at a time for analysis on the Q6000

Figure 3: FDM sample vial and dispensing the oil sample onto the felt disc using a graduated disposable pipette.

FDM. After the vials are capped, they must sit for one minute to equilibrate (per Henry’s law) and then can be analyzed on the Q6000 FDM. The device is simple to operate relying on a touchscreen interface with display and audio instructions at each step. Results display within 2 minutes and the % fuel dilution found is displays on the screen after each sample measurement (Figure 4).

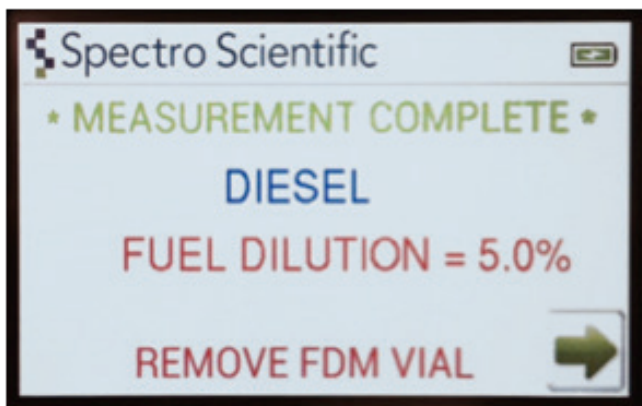


Figure 4: Results screen on the Q6000 FDM showing the % fuel dilution found for a sample using a diesel calibration program.

The results from the comparative study are shown in Table 2.

% DIESEL FUEL DILUTION						
SAMPLE	OIL TYPE	CONDITION	Q6000 FDM (% DIESEL FUEL)			GC ANALYSIS (% DIESEL FUEL)
A1	Mobil Delvac 1 ESP 5W-40	Used, Not Sooty	1.8	1.9	1.9	1.98
A2	Mobil Delvac 1 ESP 5W-40	Used, 1.2% soot	0.3	0.2	0.4	0.22
A3	Mobil Delvac 1 ESP 5W-40	Used, 1.2% soot	1.8	1.9	1.9	1.80
B1	Esso Racing 20W-50	New oil, known 13.4%	13.9	13.1	13.0	12.95

Table 2. The % diesel fuel dilution results for each test sample.

The fuel dilution % of the known calibration samples as measured by the reference GC method of the known calibration samples were A0: 5.14%, B0: 4.97%.

The results for test samples A1, A2, and A3 on the Q6000 FDM correlate very well with the GC reference method, as shown, at about 0.2 and 2% diesel fuel dilution for both lightly used and very sooty samples. To test the higher end of the measurement range on the Q6000 FDM, a calibration standard of 5% (B0) and a known test sample of 13.4% diesel fuel (B1) in Esso Racing 20W-50 were prepared. The average result obtained on the Q6000 FDM for test sample B1 of 13.3% diesel fuel is accurate to the gravimetric value and also correlates well to the 12.95% obtained by the GC reference method.

The repeatability between all triplicate measurements for the Q6000 FDM gives high confidence in the result and the sampling method. The repeatability (typical) on the Q6000 FDM is <5% RSD. An operator can have confidence using this technology in the field trusting that it will correlate to the referee laboratory method.

The Q6000 FDM is much quicker and simpler to do accurate analyses on many different types of oils on-site. It only takes 2 minutes and just one known calibration standard in order to create a custom calibration on the Q6000.

Conclusion

The Q6000 Fuel Dilution Meter (FDM) is an easy-to-use, portable, solvent-free solution for detection of fuel dilution in oil samples. Analysis takes only a couple of minutes and accurate, repeatable results are obtained immediately. Compared to the most trusted

laboratory method, gas chromatography, it is substantially less expensive, can be used by an operator without any special skill set, and provides faster results. The measurement is also easily adaptable by single point calibration to many different oil types.

References:

1. ASTM Standard D3524-14. Standard Test Method for Diesel Fuel Diluent in Used Diesel Engine Oils by Gas Chromatography.
2. ASTM D3525-04(2010). Standard Test Method for Gasoline Diluent in Used Gasoline Engine Oils by Gas Chromatography.
3. ASTM D7593-13. Standard Test Method for Determination of Fuel Dilution for In-Service Engine Oils by Gas Chromatography.
4. Timothy D. Ruppel, Gerald Hall, and Andrew Tipler, "A Novel Method for High-Speed Determination of Fuel Diluents in Lubricating Oils," Field Application Report. Perkin Elmer, 2005, Pages 1—3.