

Rapid On-Site Analysis of Fats, Oil and Grease (FOG)

Accumulations of fats, oil and grease (FOG) in the sewer line can cause sanitary sewer overflows (SSO) and impact our waterways. The Clean Water Act, which has now been governing water pollution for over 30 years, initially targeted "point source" polluters such as industrial facilities, service industries or agricultural animal feedlots.



Photo 1. InfraCal TOG/TPH Analyzer

With many of these point source problems handled, the focus has now shifted to "non-point sources" including industrial stormwater and agricultural irrigation runoff as well as SSOs – a major contributor to non-point source pollution. A recent study showed that FOG blockages account for a total of 50 to 75% of all SSO's.¹ In response to this problem the EPA, along with city and state agencies, initiated the Capacity, Management, Operation, and Maintenance (CMOM) program in 2001 to encourage operators of sewer systems to improve maintenance in order to reduce the occurrence of SSO's.

As an aid to the CMOM program, Water Environment Research Foundation (WERF) funded a report titled "Assessment of Grease Interceptor Performance"¹. Used mainly by food service establishments, Grease Interceptors trap grease, preventing it from getting into the sewer. The study evaluated different grease interceptor designs and tested the effluent for FOG levels with a portable infrared oil and

grease monitor, the InfraCal TOG/TPH Analyzer (see photo 1).

While food service establishments are a major contributor of FOG, all industrial wastewater is subject to regulations, often with oil and grease limits as low as 100ppm. For both industries and sewer treatment facilities, waiting for remote laboratory results can take several days to weeks resulting in high levels of FOG getting into the sewer line. But, with a simplified FOG analysis procedure using a portable infrared analyser, a regulator or operator can get an on-site result in less than 10 minutes.

FOG Analysis Methods

FOG is a difficult analysis because it is not a unique chemical entity. The definition of FOG is dependent on the procedure and solvent used. Because different testing methods are looking at different physical properties of FOG, there can be differences in the analysis. Infrared is primarily counting CH₂ groups so the infrared absorbance goes up with the length of the hydrocarbon chain which correlates with the weight of the hydrocarbon. Therefore, the EPA 1664 hexane/gravimetric method and infrared analysis typically correlate well with each other. Table 1 shows two sets of data comparing the hexane/infrared method to the

Meat Packing Plant		
	Infrared ppm	Gravimetric ppm
Sample 1	67	70
Sample 2	1990	2020
After Grease Trap at a Restaurant		
Sample 1	423	415
Sample 2	332	300
Sample 3	103	130
Sample 4	157	170
Sample 5	67	74

Table 1 Comparison of the Hexane/infrared Method to the Hexane/gravimetric Method

hexane/gravimetric method. One data set is from a meat packing plant and the other from tests done on a grease trap from a restaurant.

Differences begin with sample collection. It is very difficult to get two identical grab samples from a waste stream as it is typically not well amalgamated. Another consideration is recognising the inherent error in the EPA 1664 Method itself. As stated in the method in section 17.0 "Acceptance Criteria for Performance Tests" for ongoing precision and recovery, the accepted range hexane for extractable material is 78-132%. This means that for a 100ppm sample, an acceptable result from a laboratory using the EPA 1664 method would be 78ppm to 114ppm, or +/- 18ppm. For hexane extractable material that is treated with silica gel to remove the polar organics for a total petroleum hydrocarbon (TPH) measurement, the acceptable result range is 64ppm to 132ppm, or +/- 34ppm for a 100ppm sample.

Infrared Analysis of FOG

The measurement by infrared absorption makes use of the fact that hydrocarbons such as fats, oil and grease can be extracted from water through the use of an appropriate solvent. The extracted hydrocarbons absorb infrared energy at a common infrared wavelength and the amount of energy absorbed is proportional to the concentration of the oil/grease in the solvent. The infrared absorption can be directly calibrated to the amount of oil in the original sample.

Infrared analysis of oil and grease has been used in the petroleum industry on highly regulated off-shore oil platforms for over 30 years. EPA Methods 413.2 and 418.1 are infrared methods for oil and grease measurement that called for the now-banned Freon to extract the hydrocarbons from the effluent. EPA Method 1664 using hexane as the extraction solvent and gravimetric analysis is now the standard method replacing Freon methods. This gravimetric procedure requires a skilled laboratory technician and is a time and equipment intensive process. To accommodate those that need a quick, portable analysis, the ASTM passed a new method using a Freon replacement solvent, and simplified infrared analysis. There is also a simplified infrared method using hexane extraction and evaporation.

Measurement of FOG using Infrared Absorption and a Hydrocarbon Free Solvent

For an infrared measurement, FOG is measured at the C-H absorption band at 2930 cm⁻¹ or 3.4 micrometers. S-316 solvent (called for in the new ASTM method D 7066-04) or hydrocarbon-free perchloroethylene are good infrared solvents as they totally lack a C-H absorption band. The solvent extract is placed directly in a quartz cuvette and a beam of infrared light goes through the cuvette with the extract for an infrared transmission measurement (Figure 1). A detector with a 3.4µm filter for C-H absorbance measures the hydrocarbon content in the extract. The minimum detection for this method using a portable fixed filter infrared analyser is 2ppm.

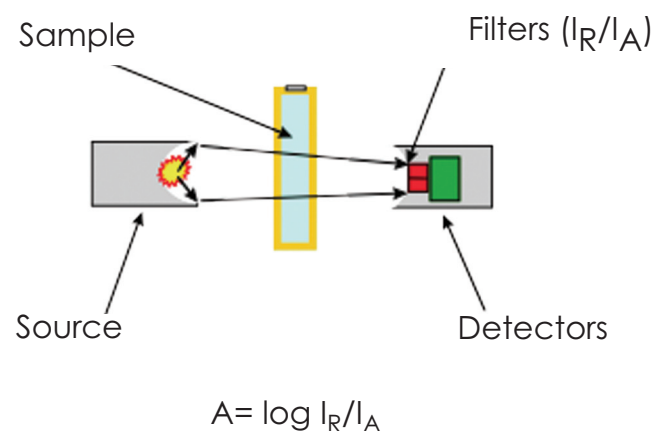


Figure 1: The Measurement of IR Absorption of an Oil Sample with a Cuvette

Measurement of FOG using Infrared Absorption and Hexane Extraction

Hexane is a desirable solvent because it is fairly easy to dispose of and it is the solvent used in EPA Method 1664. Because hexane contains hydrocarbons, it must be evaporated off so that it does not interfere with the measurement of oil and grease. This poses a problem for the traditional infrared method of using a quartz cuvette and transmission as described above. To overcome this limitation, an ATR (attenuated total reflection) sample plate (figure 2) is used as an alternate sample holder to the quartz cuvette. For this analysis, a measured amount of the hexane extract is deposited directly on the ATR crystal. The hexane evaporates and leaves a film of oil and grease on the surface of the crystal. The infrared beam is internally reflected down the ATR crystal and the output is focused directly on the detector situated at the opposite end of the infrared source. Since there is an evanescent wave that penetrates into the film of oil and grease at each internal reflection point, energy is absorbed at the C-H absorption band without the hydrocarbon interference from the hexane. The minimum detection for the hexane extraction is 8ppm.

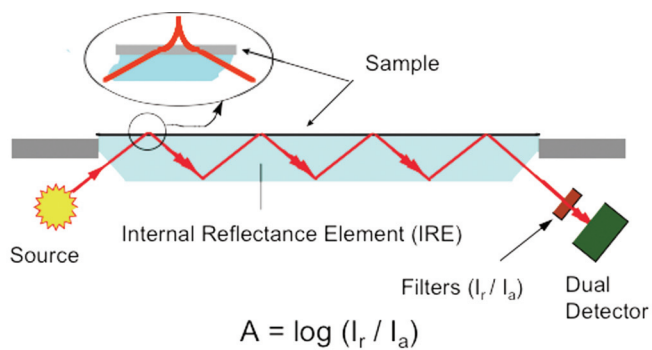


Figure 2. The Measurement of IR Absorption of an Oil Sample with an ATR Sample Plate

FOG Measurement Procedure

An advantage of infrared analysis over the gravimetric method is the ease of use and the quick analysis time. Portable, relatively inexpensive fixed-filter infrared analysers, such as the Wilks InfraCal TOG/TPH Analyser (photo 1), are currently employed by regulators and industrial pretreatment personnel for on-site testing. The extraction and measurement procedure involves several simple steps allowing an operator with minimal training to do the analysis.

The sample is collected in a container. The solvent, hexane, perchloroethylene or S-316, is added at a ratio of one part solvent to 10 parts sample. After shaking for 2 minutes the hexane, which is lighter than water, will rise to the top carrying dissolved oil and grease with it. The S-316 and perchloroethylene are heavier than water and require an inverted container such as a separatory funnel or a jar with a septum to remove the solvent.

For the hexane method the extract is placed on the ATR crystal and after evaporation (about 3 minutes) the result is displayed. For the ASTM method D 7066-04, the cuvette is filled with the S-316 or perchloroethylene extract and placed in the analyser. After 30 seconds, the result is displayed. The analysis from sample collection to final result takes less than 10 minutes.

Conclusion

Using portable infrared analysers with a simple and quick infrared procedure enables operators of a pretreatment system to easily assess their system's efficiency. In addition, regulators from a POTW can immediately determine who their "FOG clog" offenders are and how much they are releasing into the sewage system. Plant operators have the advantage of taking samples before and after treatment to see how a system functions under heavy loads. System parameters can be changed and the results of the changes can be determined without waiting a week or more for a laboratory result. Most importantly, effluent that is above the fats, oil and grease regulatory limits can be stopped before it stops the flow of the sewer line.

References

1 Assessment of Grease Interceptor Performance (Supplemental Report to 03-CTS-16T) Joel J. Ducoste, North Carolina State University; Kevin M. Keener, Purdue University; John W. Groninger, Southern Illinois University; Leon M. Holt, Town of Cary; Copyright 2008 by the Water Environment Research Foundation.

2 EPA Method 1664, Revision A: N-Hexane Extractable Material (HEM; Oil and Grease) and Silica Gel Trated N-Hexane Extractable Material (SGT-HEM; Non-polar Material) by extraction and Gravimetry, United States Environmental Protection Agency, Office of Water, EPA-821-R-98-002, February 1999.

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