Standardizing Sampling Procedures Within Emergency Generator Fuel Testing Programs

A white paper prepared by
FOI Laboratories

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History's Reminders

While the successes of emergency generators go unnoticed, the failures make headlines. The past several years have shown how varied and widespread such failures can be, such as during the 1993 Mississippi River flooding, the 1996 Northwest Blackout and Northwest flooding. Our recent memorable events were the 9-11 terrorist attacks, the July 2003 Memphis straight line windstorm, the August 2003 Northeast Blackout, the East Coast's Hurricane Isabel, California's Northridge earthquake then alternating blackouts and wildfires, numerous tornados in Midwestern states, the 2004 & 2005 Gulf Coast hurricanes and tropical storms Katrina and Rita, and most recently, the winter ice, snow and wind storms that have torn through and blanketed us from the East Coast to the West Coast triggering another wave of catastrophic generator failures.

Reactions

As a result of these events, hospitals are increasing their on-site fuel oil storage as a part of their emergency management improvements. These decisions are being made out of the necessity to survive longer potential utility outages without the ability to be reached by outside support. This increased storage capacity has caused the issue of fuel aging to become more critical. The clean fuel criterion applies to both the large fuel oil storage tanks and the local day tanks.

Informational articles and white papers have been written in regard to the reasons behind the diesel engine failures, citing reasons such as water and impurities in fuel oil due to system condition, maintenance error, fuel stagnation, storage tank corrosion, clogged or fouled fuel oil filter, day tank and large storage tank micro-organism contamination, inconsistent fuel oil quality from the supplier, incorrect diesel additive usage, and as an afterthought, inadequate sampling techniques.

It is the diesel fuel sampling techniques and imperative tests for emergency generators that are the focus of this white paper. Hospitals and other organizations accredited by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) have put generator and fuel testing issues as top ranking in their priority list. Sentinel Event Alert # 37 places the expectation of a clearly documented fuel testing process directly on each accredited agency. Engineering Associations are urging all facilities with an emergency generator to take a closer look at the way their fuel testing is being done.

Disturbing Findings

We have been in conversation with hospitals, generator manufacturers and service companies alike and have uncovered some disturbing trends.

1. Medical and other facilities expect that the responsibility for the fuel quality is in the hands of the fuel supplier- regardless of the age of the fuel.
2. Medical and other facilities choose to blindly believe that the fuel testing is being done properly and consistently.
3. Engineers and Service technicians nation wide are taking fuel samples from incorrect fuel locations while the generator is running during load bank testing.
4. Administrative personnel assume that the laboratory tests being run on their fuel samples are giving an adequate and accurate analysis of their fuel quality.
5. Filtered fuel samples being run through inadequate laboratory testing packages have been rendering a false sense of security by giving false positive findings and are at the root of the catastrophic events listed above.

The Samples

To verify these findings, we went out to medical, industrial and data center locations to conduct an independent sampling study of on road and off road fuel in long term storage tanks. We first pulled a sample using the methods described by facility engineers and service technicians as standard fuel sampling technique – from the generator filter housing. We then pulled fuel samples using the proper equipment from the locations that would give us the most accurate read on the fuel – the middle and bottom of the storage tanks. These samples were then submitted to the FOI laboratory which is overseen and operated by a degreed chemist with over 15 years of experience.

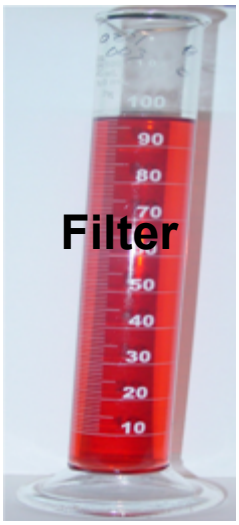
Examples of the Samples are displayed in the Figures below.

Figure 1
On-road diesel

Figure 2
On-road diesel

Figure 3
On-road diesel

Figure 4
Off-road diesel

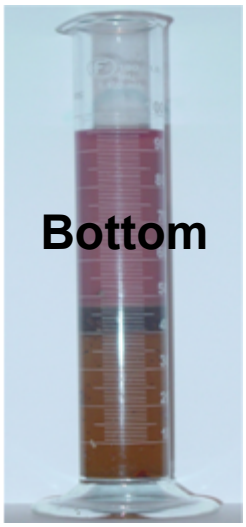


Clear of contaminants

Figure 5
Off-road diesel

Clouded with entrained water

Figure 6
Off-road diesel



Heavy water, microbial & particulate contamination

The typical method we found being used nation wide is to extract a sample from the filter housing on the generator which renders samples as seen in *Figure 1* (on-road diesel #2) and *Figure 4* (off-road diesel #2). You can see visually that the fuel has the appearance of being in good condition.

The sample in *Figure 2* was extracted from the middle of the generator storage tank that was the supply source of Figure 1. You can see visually the cloudy appearance of *Figure 2* that is created by entrained water in the fuel.

The sample in *Figure 3* was extracted from the bottom of the same storage tank as *Figure 2*. You can see the separation of the fuel with entrained water on the top of the sample and the water, particle and microbial contamination on the bottom of the sample.

The sample in *Figure 5* was extracted from the middle of the generator storage tank that was the supply source of *Figure 4*. Again, you can see a mildly cloudy appearance of some entrained water and particulate contamination.

The sample in *Figure 6* was extracted from the bottom of the same storage tank as *Figure 5*. In the dramatically layered separation of this sample you can see a small layer of red fuel on top, heavily entrained water in the pink layer of the sample, a dark layer of rust and dirt being supported by a viscous layer of water, particulate and microbial contamination.

The Laboratory Results

In our interactions with the facilities and service agencies, we found that the laboratory test packages being used not only lacked any form of standard protocol specifically designed for long-term storage diesel fuel for emergency generators but worse, the fuel samples from these emergency generator sites are being submitted with inadequate volume for true ASTM methodology and were to be tested as follows:

1. Particle Count and Wear Metals
   This test package is acceptable for testing oil, not fuel, from an engine.

2. Visual Appearance, Viscosity @ 40°, Sulfur, API Gravity, Cetane Number, Distillation, Cloud Point, Microorganism
   This test package is acceptable for testing the fuel from a loading rack.

While there were a couple variances from these two test packages, these were the standard representative test packages being used to test fuel extracted from the filter housing (as seen in *Figures 1* and *4*) on emergency generators with long-term storage tanks.

As could be expected, the laboratory test results from this combined sampling methodology and inadequate test package showed no signs of contamination and certainly gave no reason for facility administrators to be concerned.

By way of comparison, the long-term storage emergency generator test package that was developed out of the collaborated efforts of the FOI Research and Development department, Laboratory Chemist and collective 95 years of fluids analysis experience is as follows:

Test	Units	Method
API Gravity	Degrees API	ASTM D1298
Dissolved Water by K.F.	PPM	ASTM D6304
Distillation, IBP	Degrees F	ASTM D86
Distillation, 10% recovery	Degrees F	ASTM D86
Distillation, 50% recovery	Degrees F	ASTM D86
Distillation, 90% recovery	Degrees F	ASTM D86
Distillation, End Point	Degrees F	ASTM D86
Distillation, % recovery	Vol%	ASTM D86
Cetane Index		ASTM D976
Particulate Contamination	mg/Gal	ASTM D6217
Sediment & Water	Vol%	ASTM D2709
Stability / Accelerated Aging	Du Pont F21-61	Du Pont F21-61
Flash Point	PMCC	ASTM D93
Sulfur	ppm	ASTM 5453
Microbial Growth	pos/neg	Microscopic/Culture Growth

Figure 7

The combination of tests in *Figure 7* gives the clearest picture of the fuel life and quality for the fuel in the long term storage tanks of emergency generators. Other tests may be added based on environmental factors. The results sought in this test package are found in the descriptions below:

AEROBIC BACTERIA
Aerobic Bacteria testing determines the presence of bacteria and how many colonies there are.

API GRAVITY
API Gravity is the measure of a diesel fuel's density, or weight per volume. The higher the API Gravity, the less dense the fuel. API Gravity can provide valuable information about a fuel's composition and performance characteristics including power economy, low temperature properties and smoking tendencies.

BACTERIA, FUNGI, AND MOLD
Bacteria, Fungi and Mold are indications that fuel storage tanks have not be properly maintained. Water can build up at the bottom of storage tanks and create an excellent breeding ground for biological growth.

DISTILLATION
Distillation temperature is the temperature at which 90% of the fuel volume can be distilled off. This temperature is directly related to the fuel's volatility and therefore, it's Cetane Index, density, flash point and viscosity as well. A #2 diesel fuel's minimum distillation temperature should be approximately 300° F and its maximum should be approximately 700° F.

FLASH POINT
Flash Point is the lowest temperature at which the vapors of a combustible liquid will ignite momentarily in air. Low diesel fuel flash points indicate contamination by more volatile fuels such as gasoline.

SULFUR
Sulfur content will affect SOx emissions and can have adverse effects on many NOx and PM emission reduction devices. The amount of sulfur allowed in diesel fuel is regulated by the government. Bulk delivery of diesel fuel should be tested to include sulfur levels.

WATER & SEDIMENT
Water & Sediment in fuel can cause corrosion, wear, bacterial growth and premature fuel filter clogging. The amount of water in fuel should not exceed 500 ppm (0.05%). Sediment should be no greater than 100 ppm (0.01%).

STABILITY / ACCELERATED AGING
This gives the ability to forecast the way the fuel will respond with age and exposure to heat. There are many requirements now mandating that facilities document the age of the fuel and show that there is a process for tracking the age of the fuel and showing the plan for replacing fuel aged past its usability. FOI is working with other affiliated companies, developing alternatives to the costly process of fuel replacement.

This test packaged in conjunction with the proper, standardized sample extracting methods and FOI's solution-based analysis, create a process which renders consistent, accurate and trackable results.

Become the Solution

First is the matter of reviewing your current process. What methodology is being used to extract the fuel samples? What testing package is being used on the fuel sample? What if any industry recommendations are being given within the analysis?

Next is the matter of training. FOI has become part of the solution by developing a standardized emergency generator testing package, a technician/engineer training package complete with proper sampling equipment, a pre-packaged fuel testing solution for re-sellers and a fuel sampling protocol; all of which combine to form a seamless process for successful fuel testing procedures. Medical facilities and generator service companies should ensure that their engineers or technicians have the proper sample extracting equipment and the training to know where the samples should be extracted from. The volume size of the storage tank determines how many samples should be taken per test cycle. A tank of less than 500 gallons should have a 16 oz. sample extracted from the middle of the fuel in the storage tank and a 4 oz. sample extracted from the bottom of the fuel in the storage tank. A tank of 500 gallons or greater should have a 16oz. sample extracted from the middle and from the bottom of the fuel in the storage tank, the combination of both tests rendering the most accurate results. Test properly to establish a true fuel quality baseline and then follow the recommendations of the laboratory's chemist.

Finally, have an open communication line with your fuel testing laboratory. Make sure that your fuel tests are first in line, not sitting behind the priority of oil or coolant samples. Interact with the laboratory chemist with any questions that you may have and get your answers directly from the scientist that is doing your fuel analysis. Look at your fuel testing history and talk to the laboratory consultants about recommendations for potential sampling and testing needs.

By having a standardized testing procedure within your Emergency Generator Testing program, you can feel more comfortable knowing that when disaster strikes, you will keep yourself in business and out of the headlines.

About FOI Laboratories

FOI Laboratories is a state-of the-art fuel analysis, testing and research laboratory that specializes in providing high quality fuel analysis and testing services to commercial and industrial businesses. The company offers comprehensive testing services for diesel, bio-diesel, jet fuels and marine bunker fuels that have been designed to detect storage integrity and classify product by ASTM and industry specifications.

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