

Diesel Generator Failures: Lessons Taught by Hurricanes

By David Eoff, Preferred Utilities

During the 2005 U.S. hurricane season, power outages were widespread, calling a great many diesel generators into service. While most started and delivered much needed power to their facilities, many failures were reported as well. Generator providers and their service technicians learned a great deal during these emergencies and now are applying knowledge learned from those lessons to avoid future failures. The Gulf Coast had a quiet hurricane season in 2006, but the next major hurricane to hit the United States is certainly a matter of when, not if. Understanding the reasons generators failed during the storms of 2005 and applying some of the lessons learned may help ease future emergencies.

When diesel generators fail to start, the most common culprits are:

- Fuel contaminated by sludge, water or asphaltines
- Dead or weak starting batteries
- Failed engine-cooling systems.

Sludge contaminating the fuel tank will clog fuel lines, filters, strainer baskets and fuel injectors and lead to corrosion of essential engine parts. The key to maintaining good fuel quality is in understanding the processes that cause fuel degradation. Diesel fuel is an organic, refined product. It begins to decay as soon as it is refined. Sludge formation is an organic process caused by bacteria, fungus and other biological agents—especially in the presence of water. That’s why the sludge in a diesel tank sometimes is referred to as “biofilm.”

The first step to preventing biofilm buildup in the fuel tank is proper tank design to restrict the entrance of water through vents, leaks and fill boxes. Sidewalk fill boxes and in-wall fill boxes must be designed so that rainwater (and potentially seawater) is prevented from entering the fuel tank. Fill caps must be watertight,

especially in underground fill boxes where water could accumulate. Interstitial leak detectors should be installed in the annular area of double-walled tanks. These can discriminate between water and oil and activate an alarm to notify facility personnel of a problem.

Even with proper fuel-system design, it is possible to get water in the fuel tank as part of the delivered fuel and by condensation through fuel vent lines. Condensation is an especially serious problem on the Gulf Coast, where the relative humidity tends to be high and ambient temperature changes are frequent. Most fuel-filtration systems include a coalescing filter to remove water from fuel. Fuel-filter systems can range from portable units that

can be rolled from tank to tank, to permanently installed, multi-tank filtration systems that automatically filter, dewater and continuously add a chemical stabilizer to the fuel. Services also exist that will bring truck-mounted fuel-filtration equipment to a site to periodically clean and dewater the fuel. The cost usually is assessed on a per-gallon basis.

The best scenario, from a fuel-quality standpoint, would be to turn over the fuel supply by using the fuel on a regular basis through exercising the generators and/or boilers. In practice, however, this scenario has several flaws. First, the weekly exercising of generators consumes very little fuel, so there would still be a large amount of potentially contaminated stored fuel even in small systems. Second, facilities store large volumes of fuel on-site and there is often no practical way to consume

enough fuel to maintain a fresh fuel supply. Third, with the rising cost of fuel and a potentially unstable oil market, consuming fuel just to keep a fresh supply can be quite costly.

“The most reliable method of maintaining a clean fuel source is a permanently installed, automatic fuel-filtration system,” said Sean Smith of Cougar Sales in Houston. “We have been involved

TABLE 1 DIESEL GENERATOR SERVICE CHECKLIST

Maintenance Items	Service Interval				
	Daily	Weekly	Monthly	6 Months	Yearly
Inspection	x				
Check coolant heater	x				
Check coolant level	x				
Check oil level	x				
Check fuel level	x				
Check charge-air piping	x				
Check/clean air cleaner		x			
Check battery charger		x			
Drain fuel filter		x			
Drain water from fuel tank		x			
Check coolant concentration			x		
Check drive belt tension			x		
Drain exhaust condensate			x		
Check starting batteries			x		
Change oil and filter				x	
Change coolant filter				x	
Clean crankcase breather				x	
Change air cleaner element				x	
Check radiator hoses				x	
Change fuel filters				x	
Clean coolant system					x

Source: Cummins Power Generation

in projects that rely solely on an annual maintenance schedule utilizing truck-mounted fuel scrubbers. The problem with this is you put the lifeblood of your critical power system in human hands and mistakes are bound to happen. We recently did a fuel-control system upgrade at a facility that had just hired one of these truck-mounted units to come and scrub the main fuel-storage tanks. Once we started our control system, we found that there was still six inches of water in the tank.”

National Fire Protection Association (NFPA) standards require a clean fuel supply be provided to emergency generators and recommend maintaining fuel on a weekly basis. “Fuel can be stored in these large systems for years,” Smith said. “If you found an old gas can at your house that had been sitting for years, you wouldn’t put that old fuel in your car or lawnmower. Why would you want to put it in a critical fuel system?”

Weekly generator tests are recommended but usually will not consume enough fuel to prevent fuel degradation. However, if backup diesel generators can be supplied from the same fuel tanks that supply boilers, trucks or other continuous users, fuel consumption may be high enough to keep the fuel fresh. Be sure to check the fuel specifications for each piece of equipment to ensure they all can operate from the same tanks.

Battery failure is the second leading cause of generator failure. Lead sulfate buildup on the lead plates of lead acid batteries will cause a reduction in cold cranking amps. Proper battery maintenance and recycling batteries every three to four years are recommended steps. In addition, battery connections can become loose or corroded. Charging systems can fail or be turned off inadvertently, resulting in dead or undercharged batteries that won’t start a generator. Regularly scheduled generator tests will give operators the opportunity to test the battery systems as well.

Failed coolant systems are the third most common culprit when a generator fails to start. A hospital in Longwood, Fla., lost power in 2007 and its emergency generator failed to start. This prompted local authorities to go into “mass casualty mode,” according to local news reports. Several of the 180 patients at the hospital had to be evacuated. Facility engineers determined that the diesel generators failed to start because of a coolant leak. The local electric provider restored power two hours later.

Coolant systems need to be part of a regularly scheduled maintenance and

inspection procedure. A typical inspection regimen consists of visually inspecting the coolant system for leaks, drips, puddles or crusty areas that indicate evaporated engine coolant. A visual inspection of cooling hoses should be conducted as well. Worn, cracked or loose hoses should be repaired or replaced.

Cummins Power Generation, a leading supplier of diesel generators, recommends a regular inspection regimen covering the exhaust system, fuel system, DC electrical system and the engine itself.

Coping with Hurricanes

The Gulf Coast region, susceptible as it is to hurricanes and tropical storms, poses its own problems for standby diesel generators. Some of the problems are exacerbated because natural gas is abundant in these areas, so facility engineers do not have the oil-handling experience of their counterparts in the northeastern United States, where oil often is burned through the winter months. Facility managers in the Gulf Coast region understand that they may be on their own for days during and after a hurricane.

“Sometimes it’s hard to get a service technician to a site with all the chaos after a storm,” said Mike Jennings, Louisiana Machinery’s electrical power business manager. Louisiana Machinery is the Caterpillar dealer in New Orleans. “Magnify all the things that happen in a natural disaster, and it can be hard to find a service person.”

With the widespread flooding caused by Hurricane Katrina, many generators failed because they were underwater shortly after the storm hit. A common practice now is to elevate diesel generators and fuel tanks above typical storm-surge levels. If generators can’t be installed in the second story of a building or higher, sometimes they are lifted on platforms approximately one story high. In fact, in response to recent hurricanes, the Florida Division of Emergency Management now requires generator sets to be located above storm-surge or 100-year flood levels.

Joe Langston, electric-power business manager for Thompson Power Systems in Mobile, Ala., said that diesel generators not only need to be higher than storm-surge levels, but that in Florida they must be designed for wind and impact load, including a code requirement to “resist penetration by a nominal 2” by 4” lumber plank weighing nine pounds traveling at 34 miles per hour and striking end-on and normal to the structure’s surface.”

Power outages after hurricanes can last for several weeks, requiring extended generator

runs and the need for refueling. A hospital in Beaumont, Texas, ran its generators for 14 days after Hurricane Rita. Because of a high water table and local regulations limiting the amount of above-ground fuel storage, this hospital required a fuel-delivery truck nearly every day during its generator run.


As a result of local regulations that limit above-ground, on-site fuel storage, many facilities are buying diesel engines with the largest belly tanks available. Belly tanks are considered part of the engine and don’t count toward above-ground fuel-storage limits. Beaumont received substantial damage from Hurricane Rita, but most of the critical roads were opened quickly after the storm. In many areas of southern Louisiana, roads and bridges were closed for weeks after Hurricane Katrina, making it difficult or impossible for fuel-delivery trucks to reach customers.

Detroit Diesel reminds customers in installation manuals for its engines that regulatory codes that require backup power often specify minimum on-site fuel supply. These include NFPA 70 National Electric Code and NFPA 99 Standard for Health Care Facilities. However, increasing on-site fuel storage means oil is likely to sit for longer periods of time in the tank. This makes the installation of a proper fuel-filtration and dewater system even more critical.

Some generators have a dual-fuel capability. The generators start on diesel fuel and then natural gas is introduced through the engine’s air intake. “Natural gas can offset 60 to 70 percent of the Btus (British thermal units) consumed by the engine,” according to Jennings.

Emergency backup power is required for many facilities. Owners of these facilities spend a great deal of money installing the necessary equipment for on-site power generation and for electronics to control and monitor backup power systems.

The engineering and maintenance practices outlined above add little or no extra cost but can help prevent costly outages when these critically important generators are called into service. Proper system design, maintenance and inspection and periodic testing are required to ensure these systems will provide power in an emergency situation when it is needed most.

When the lights go out, it’s too late. 

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