Averting Common Causes of Generator Failure:

Understanding How to Properly Maintain Your Standby Power System.

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Most people spend more time and energy going around problems than in trying to solve them.
-Henry Ford

Knowledge is ***power***.
- Sir Francis Bacon

Introduction

Today, companies are more than ever dependent on a continuous supply of electric power. To safeguard their facilities from the disastrous consequences of power disruption, many companies are choosing to invest in standby power systems.[1] Standby generators and automatic transfer switches are two essential components of this continuous power solution: "They … [continuously] monitor the supply of electrical power… [to the facility], and if there is a loss of power, the automatic transfer switch will start the standby generator and transfer… [the facility load] to generator power."[2] This availability of continuous power helps a company maintain operation, avoid revenue loss, and ultimately, protect the bottom line; providing the advantage of reliability when competitors go down.

Investing in a standby power system is a costly expense; therefore, it is only logical that a company understands how to properly use and take care of their power equipment to ensure clean, continuous power for their business operations. A lack of generator maintenance or operation knowledge will without a doubt result in generator failure.

This paper will discuss what is necessary in ensuring the reliability of your company's standby power system, by addressing two key issues:

1. The importance of possessing a comprehensive understanding of the power equipment being utilized; and,

[1] For more information, consult "Contingency Planning for Disrupted Electric Power: The Case for Partnering with a Strong Rental Power Supplier." Peterson Power Systems/CAT.
[2] Norman, Tim. "Generator and Transfer Switch Maintenance." The University of Delaware: Applied Poultry Engineering News Vol.2 No. 2, April 2004.

2. The benefits of an established "baseline set of values that can be referenced during routine and ongoing maintenance."[3]

These two issues will be further emphasized through a discussion of common reasons why generators fail to start, and how these failures can be easily avoided if the customer is properly trained in power equipment and keeps up with preventative maintenance.

Know Your Power Equipment: A Review

Power equipment is built to be safe, reliable, and capable of handling heavy electrical loads upon demand. As power requirements increase and power equipment becomes more complex, the handling and upkeep of a standby power system must become a higher priority. "It is critical to confirm that the generator system control settings are properly set and functioning not only at the startup of the project, but remain set through the life of the project. These settings may need to be tweaked as the load profile of the building or the reliability of the serving utility changes."[4] A proper understanding of the operation and various components and settings of your generator system will ensure a quick and efficient response to power disruption, planned or unexpected.

Automatic Transfer Switches (ATS):

Automatic Transfer Switches (ATS) allow a smooth, immediate, synchronized transfer of electrical current from a generator set to a facility's load. The ATS continuously monitors a business's power quality, and is able to automatically start the generator set to restore electricity to the load when utility power is interrupted. When utility power is restored, the ATS switches the load from the generator back to the utility system, and automatically shuts itself down when the generator is completely disconnected and primary utility service is restored.

[3] http://www.csemag.com/article/CA602440.html
[4] http://www.csemag.com/article/CA602440.html

It is essential that you know the make (specifically, the manufacturer, model number, and style) of the automatic transfer switch you are using. This information may be located on the inside door or cabinet of the ATS, or in the owner's manual. Learn the purpose and location of the various devices (switches, lights, screens, and buttons). If needed, label these devices so that their purpose is clearly defined. In the event of a failure, this information will help you operate the ATS manually. (Large power surges, like lightening strikes, can cause automatic transfer switch failure.) If you have questions and/or concerns about manually starting the automatic transfer switch, contact qualified electrical companies and/or power suppliers for instruction; their contact information should be taped inside the transfer switch for easy access.

Diesel Generators:

Standby generators are an integral part of business continuity planning; but while companies invest hundreds of thousands of dollars in this type of equipment, often generators fail to properly start when needed. Generators are composed of various systems – the cooling system, the fuel system, the battery and charging system, the engine, and the generator controller – that must work together smoothly for the unit to operate properly.

- **The Cooling System:**

The cooling system contains a radiator, antifreeze, a block heater, and a water pump.

Radiator fins must be inspected on a monthly basis and cleared of all dirt and debris. "Make sure the generator is OFF prior to inspecting by shining a light through the front of the radiator. If the light doesn't shine through the fins, carefully clear the blockage."[5]

Antifreeze levels should be checked on a weekly basis.

Make sure the block heater is plugged in and warm. Block heaters should be plugged in year round, as they reduce wear on the generator's engine.

Inspect hoses and the water pump for signs of wear, bulges, cracking, and leaks; check the hose clamps for tightness.

- **The Fuel System:**

The fuel system is made up of a fuel tank, filters, fuel lines and hoses, lines connecting the generator to the fuel tank, fittings, regulators, and fuel additives. The fuel filters in diesel engines should be changed at least once every year.

Know what type of fuel is required, the capacity of the fuel tank, and the estimate fuel consumption rate for the unit at 75 percent load and 100 percent load.

Pay note to whether wet spots appear around the fittings.

- **The Battery and Charging Systems:**

Batteries must be functioning properly for the generator to be able to instantly start.

The charging gauge (or indicator light) should read OK on the battery charger.

[5] Norman, Tim. "Generator and Transfer Switch Maintenance." The University of Delaware: Applied Poultry Engineering News Vol.2 No. 2, April 2004.

Make sure the battery and charger connections are tight, and clean any corrosion off the terminals. The battery charger must be turned off before working on the battery or the starter.

- **The Engine:**

Know the manufacturer of the generator engine and unit, the model number, and kW rating of the generator set. This information is required when calling for service on the unit.

Inspect the engine for leaks and wear.

Check engine belts for wear, cracking, splitting, or looseness.

Check oil levels. The engine oil needs to be changed once every year.

Inspect the air filter to make sure the filter canister does not contain dirt or other debris. The air filter needs to be changed once every year.

- **The Controller:**

The controller is a vital part of a generation system. The controller monitors all the engine and generator functions, such as: the engine speed for hertz, the oil pressure, and the water temperature.

It is important that you know how to start the generator manually. Knowing where the gauges, dials, and buttons are located on the controller, and how they function, will ensure quick and productive action in the event of an emergency. Knowing the size, type, and voltage of the fuses, will allow you to purchase extras to have on hand for protection against downtime due to dead fuses.

With today's complex standby power systems, it is important that you understand the basic settings of your system, the method and procedures involved in proper regular maintenance, and the protocol to deal with alarm conditions in the case of system failure. This information will keep you from wasting valuable business time over generator failure due to inaccurate settings or neglected maintenance. This point will be further emphasized in the following discussion of common reasons for generator start-failure, and what can be done to avoid these "no start" situations.

COMMON REASONS FOR GENERATOR START-FAILURE

1. Battery Failure:

The single most frequent service call for generator failure is battery failure. Eighty percent of all battery failure is related to sulfation build-up – the accumulation of lead sulfates on the plates of lead-acid batteries. "This build-up occurs when the sulfur molecules in the electrolyte (battery acid) become so deeply discharged that they begin to coat the battery's lead plates."[6] When enough plate area has sulfated, the battery will not be able to provide enough current and will normally need to be replaced.[7]

There are numerous reasons for sulfation build-up:

- Battery failure is commonly the result of low electrolyte levels – battery plates exposed to air will immediately sulfate.[8]

- Batteries that are always on a charge use water. Today's newer maintenance free batteries allow water to condensate and refill their cells. As soon as the plates are exposed, the battery is junk.

- Battery cells are shorted when sedimentary trays fill up with lead debris. Shorted batteries can be avoided if batteries are replaced every three years. Batteries over three years old are very likely to fail or become weak.

[6] http://www.batterystuff.com/tutorial_battery.html
[7] http://www.ibsa.com/www/faqs/tech_talk/terms/s.htm
[8] http://www.batterystuff.com/tutorial_battery.html

- Battery failure will result from open cells; however, this is not a common occurrence. Open cells are the result of an over current of the battery system. When a generator has had several battery failures determined to be caused by open cells, the unit may require larger batteries capable of higher CCAs.

- Frequently, battery failure is due to the charger breaker being open or tripped; this is most often the result of human error rather than actual charger failure. This usually occurs after service on a generator, or some type of maintenance, where the charger has been turned off and not turned back on again when the service is completed. The unit's various alarms should catch this error before an attempt is even made to start the generator; to name a few: Charge Fail, AC Fail, Low Battery, and a General Failure Alarm. This type of failure is an excellent example of why it is important to remember that no matter who services your generator, humans make mistakes. Always double check a generator system after any service or maintenance to make sure that everything is in proper functioning order.

Battery maintenance is an important issue. Many battery problems are caused by dirty and loose connections. Cable connections need to be cleaned and tightened. Battery charger failures are difficult to prevent, and cannot be accurately predicted. However, monitoring the charge rates from month to month will establish a trend that can help map the potential for failure. A properly functioning battery charger will have a constant charge rate for any given system. An increase of amperage may show signs of a battery or charger malfunction. Any sudden change in the charge rate for no apparent reason is cause for further investigation of the charging system.

2. Low Coolant Level Alarms/ Shutdown:

The most obvious cause for a low coolant level is either an external or internal leak. Close attention should be paid to notice any visible puddles of coolant during weekly inspections of the unit(s). The color of the coolant varies by manufacturers and may look like red-dyed diesel fuel. Oil should also be inspected for any signs of a change in color or a milky texture. Hoses should be inspected for "crusties" – the sign of coolant seeping and the additives drying up at the connection.

While many generators are equipped with this alarm, few generators have a dedicated alarm indicator for low coolant. Commonly, this alarm will be tied into a high coolant temp shutdown. If the generator is equipped with an "Approaching High Coolant Temp Alarm" or "High Coolant Temp Pre Alarm," you can determine which fault caused the shutdown. If the high temp shutdown is activated without a pre alarm, it is most likely responding to the coolant level.[9]

Internally plugged radiator cores will also cause low coolant level shutdowns. When the generator is under load, the thermostats open completely and the radiator cannot allow the proper amount of flow through the core. The coolant has to go somewhere, and so purges through the overflow line. As the engine cools off and the thermostat closes, the level drops and activates the low coolant level shutdown. This also occurs when float switch type coolant level sensors are used and the lines are plumbed to the top and bottom radiator tanks. When the thermostats open, the path of least resistance is through the float switch lines and the flow causes the float to drop and shutdown the engine. The thermostat will not open enough to cause this during regular weekly running of the generator. The generator will have to be tested under load to cause the thermostats to open completely. A full load test with an external load bank is the only accurate way to check a cooling system.

3. Low Coolant Temp Alarms:

A generator may need to be started up and allowed to run for a few minutes at no load so that the temperature comes up. This is not normally necessary, but will calm uncertainty over whether the generator will start cold or not.[10] Low Coolant Temp Alarms are mainly the result of faulty block heaters. Block heaters run 24 hours a day, 7 days a week, and periodically, they are going to fail. A block heater, however, will never cause the engine not to run.

Why have block heaters? A common misconception is that the engine does not need a block heater in California. A block heater does more than help the engine to start in cold weather. Due to the dissimilar metals that the engines are built with, accelerated wear can occur during start up. The pistons, normally made of aluminum, will expand at a faster rate than the iron cylinder liners. This rapid expansion of the

[9] It must be noted, that there are reported service calls where the pre alarm sensor was faulty and did not trigger the alarm.
[10] Pre-combustion chamber engines may have a problem starting; however, there are very few pre-combustion chamber engines still around. Some lean burn natural gas or propane engines may have starting difficulties when the weather is cold if they are not equipped with a choke.

pistons can lead to scuffing of the piston skirt. Block heaters relieve most of this scuffing by maintaining the cooling system temperature and keeping the cylinder liners expanded.

The extreme temperature inside the block heater is what causes the coolant to circulate through the system. (At times you can hear the coolant boiling inside of the block heater.) The block heater's high temperatures flash off the coolant into small amounts of steam, causing the coolant to evaporate in slight amounts. While it takes a long time to show a difference in the coolant level, recording the amount of coolant added to the system will help establish a trend. (The block heater thermostat is located at the cold side of the heater.) If the engine is continuously using coolant with no signs of leakage, oil samples should be taken and analyzed, and further troubleshooting should be done. If the block heater temperature gets excessively high, premature block heater failure or extreme engine damage may occur. Some generators use a control panel to operate their block heater, particularly Onan's Power Command panel.[11]

Normal walk through inspections should include checking the cylinder head (or engine thermostat housing) for temperature and verifying that the engine or block heater hoses are warm. The temperature setting should be between 90 and 100 degrees, and never more than 120 degrees. The temperature gauge may read a different value than the thermostat setting.

4. Leaks – Oil, Fuel, or Coolant:

Leaks can be prevented by routine maintenance planning. Most often oil leaks are not in fact leaks, but the result of "wet stacking" (or "engine slobber") caused by excessive no load run time. Diesel engine generators are designed to operate with a load; most effectively in the 70-80 percent range of rated output. When generators operate considerably below the rated output level, the engine can start to over-fuel or "wet stack" and damage the engine. Wet stacking - an accumulation of carbon particles, unburned fuel, lube oil, condensed water and acids in the exhaust system - is caused by the injection tips carbonizing and disrupting the fuel spray pattern. Diesel generators used for commercial purposes undergo load applications that continuously vary between efficient and low output conditions. In these applications, the generator is often paired with an automatic load bank, which will place a false load on the generator

[11] You may notice that block heater hoses are cold in these systems. This is normal and is not necessarily a problem with the block heater.

system; keeping the engine properly loaded and preventing a “wet stack” condition. When a diesel engine wet stacks, the engine will need to be cleaned up by loading the unit for a few hours and burning off the excess fuel. If a diesel engine generator steadily runs loads considerably below the rated output level, it will wet stack. For this reason, it is important that you are using a generator properly sized and designed for your needs.

Another cause of oil leak complaints is directly related to the crankcase breathers. Most engine crankcase breathers vent directly under the engine. The fumes that come out of the breather contain an oil mist. This mist can produce a puddle under the engine and coat the generator and radiator with an oil film that collects dirt and debris. Re-circulating breathers are available that can separate the oil and return it to the engine; remaining fumes get returned to the engine air intakes.

The most common coolant leak occurs in the block heater hoses. Extreme temperatures on the outlet make block heaters hard on their hoses. It is for this reason that rubber hoses should never be used for block heaters; silicon hoses are specifically designed for use with block heaters. Isolation ball valves should always be installed for block heater hose connections.

Cooling system maintenance will help prevent leaks. Replacement of hoses and coolant every three years is recommended. Generators using newer extended life coolant should still have hoses replaced and the additive package upgraded every three years. Cooling system anti freeze protection and conditioner should be maintained to the manufacturer’s specifications. Radiator core damage is directly related to the coolant that is in the system. Poorly maintained coolant will cause liner pitting and eventually severe engine damage.

Most fuel leak service calls are due to overfilling of the base tank. This is due to either human error or a failure of a pump system. Do not try to manipulate the fuel system into doing something that it is not designed to do. Remote tank pump systems and emergency shut off systems should be checked periodically for proper functioning. Flexible fuel lines should be checked regularly for cracks and signs of aging.

5. Controls Not in Auto:

Ninety-nine percent of service calls received for generator controls "not in auto" are the direct result of human error. The obvious reason for "Not in Auto" is the main control switch left in the off/reset position. This usually occurs after testing or servicing of a generator. After any service is performed on a unit, always double check the generator system yourself. The technician's feelings will not be hurt by checking his work.

The control switch may have several positions as in "Off/Reset" and "Cool Down" which will cause the generator not to start in the event of a power outage. These positions should give an alarm. "Not in auto" is a generic term for the unit not being shut off, and may not actually be the main control switch. Alarms not reset, breakers open, switch gear not reset, emergency stop buttons activated, are all examples of "Not in Auto" failures.

Several generators are set up to short trip the main circuit breaker during an emergency fault shutdown. When the generator shuts itself down (for any reason), someone has to physically reset the control panel to clear the alarm. There may be several things to check and reset after a fault shutdown; however, this should only be done once the cause of the alarm has been identified and corrected.

Ground fault sensors are required by certain building codes or engineers during construction, and must be added onto a generator. These sensors look like light switches that are turned off. Ground fault sensor shutdowns can be difficult to spot; they are not always tied to an audible or visual alarm. It is important that you determine if your standby generator is equipped with one of these sensors and how to reset it. If the generator uses remote switch gear, the switch gear will normally have to be reset. It is important to know your system and what it does during a fault shutdown. Simulate a fault to see what it takes to get it running again in the event of an emergency.

6. Fuel Bled Back into the Tank / Generator Will Not Start:

This is a common problem with newer generators that are not run on a regular basis. Closer tolerances within the fuel systems to meet today's emission requirements make fuel systems more susceptible to air

effecting start up. This is not as common with older generators. Older generators that experience this problem may have a leak in a line or check valves that are not properly holding the fuel in the engine.

Lighter low sulfur fuel has lower flash temperature, which causes the block heater to flash off some of the fuel within the injectors. One small bubble of air within a unit injector solenoid can cause an injector not to fire at start up. If enough injectors do not fire, the engine will not start. This failure is 100 percent preventable by periodically running the engine during weekly inspections. The engine does not need to be run until the coolant temp comes to normal. All that is needed is enough time to verify that the engine will start, that the air is cleared from the fuel system, and that the generator comes up to voltage and frequency. This can be completed in less than five minutes. Any additional test running would simply burn up fuel and air quality maintenance run time.

7. Engine Ran Out of Fuel:

Mechanical fuel level gauges may not always be accurate. Unlike a vehicle that is moving and using a higher percentage of its tank's capacity, a generator tank has no movement; causing the fuel to become stagnant. Mechanical gauges may also stick in a position until vibrations break them free.

Low level alarms must also be addressed, as they provide the same failure alarm. Some generators are equipped with "Low Low Level Shutdown" or "Critical Fuel Level Shutdown." These shutdowns are there to prevent the fuel system from drawing in air when running out of fuel is eminent.[12] Bleeding air out of a fuel tank can be an extremely difficult procedure.

Running out of fuel due to plugged fuel filters can be prevented by maintaining the fuel tanks, and periodically checking them for water and contaminants. Water or moisture in fuel can be damaging to diesel engines because the water properties create advanced ignition and accelerated detonation. It is also important to build relationships with fuel vendors that you can trust and rely on to deliver clean fuel. If you use fuel polishing as an alternative to cleaning your fuel, check with your vendor to see if their fuel is affected by the chemicals; fuel polishing may not be able to remove water.

[12] This shutdown alarm was not very popular in the Y2K days. If your generator was installed during this time, you may wish to retrofit it, as it most likely will not have this alarm.

Fuel filter plugging should be expected with the new ultra low sulfur fuel, which has a very high detergent level and will clean out your lines and whatever else it is in contact with.

Engines equipped with electric shut off solenoids should always have a manual bypass. There are several reasons to have shut off solenoids; large remote above ground tanks can gravity feed to the engine, over pressuring the seals in the pumps or injectors, and causing the fuel to mix with the oil. Solenoids should be DC power activating at the time of initial crank signal, and remain open until after the engine makes a complete stop.

8. High Fuel Level Alarm:

High Fuel Level alarms are required by government regulations to prevent the overfilling of a fuel tank. The alarm should activate when the fuel tank reaches between 90 and 95 percent capacity. This lets the person fueling the tank know when they should stop filling. There is normally nothing wrong with the generator when this alarm activates. On rare occasions the natural thermal expansion of the fuel will cause the alarm to activate. This will usually occur on an extremely hot summer day. High fuel level alarms may or may not clear themselves when the fuel level drops below the set point. You may have to manually reset the alarm when the fuel level drops.

9. Breaker Trip Not Related to the Generator:

This service call will usually come in as “We are in a power outage and the generator doesn’t start.” First, verify that nobody has accidentally pushed a remote emergency power off switch.

If a breaker trips after the automatic transfer switch, the generator will not start. The status of the automatic transfer switch should be checked during a power outage. The ATS should have some kind of lights or display showing the switch position and source availability. The correct position in which to check a breaker is down stream from the transfer switch. If a breaker is found to be tripped, make sure you can determine the cause of the trip prior to resetting.

Never try to manually operate an automatic transfer switch if you do not know how to do so properly. Severe bodily injury or immediate death can occur. The transfer switch is smarter than you may think and has a specific reason for being in the position that it is in; attempting manual operation may drag you into a live bus if it is done incorrectly.

10. "My Generator is Running!"

Your company should have an active plan in place when your facility moves to standby power. A well-maintained emergency or standby power system will operate completely on its own without any user intervention. The system needs to be able to do its job. After a local power outage, many service calls come in stating that "utility power is back on and the generator is still on." There are a couple of reasons for this. One reason is a delay timer in the automatic transfer switch that will keep the generator online until the automatic transfer switch sees a steady supply of clean power coming from the utility grid. This timer is usually set between fifteen and thirty minutes. Any glitch in power within that time will restart the timer. Another reason the generator will stay online is the In Phase Monitor. The automatic transfer switch may be set to have the phase angle of the generator match the phase angle of the utility grid prior to retransfer. If an In Phase Monitor is used, never set the generator frequency to exactly 60.0 Hz. If the generator and the utility are both at exactly the same frequency, the generator may take an extremely long time to match phases.

Conclusion: The Power of Sticking to a Preventative Maintenance Plan

A standby power system requires routine maintenance to guarantee power security. "Your generator is your only line of defense when [your facility] loses power. A generator usually doesn't have a backup. A lack of generator maintenance will result in generator failure."[13] Efficient performance is dependent on regularly scheduled maintenance.

The normal maintenance requirements for a diesel generator are about the same as the requirements for a diesel engine vehicle – checking oil, oil filters, air filters, and fuel filters. Standby generator engines need

[13] Norman, Tim. "Generator and Transfer Switch Maintenance." The University of Delaware: Applied Poultry Engineering News Vol.2 No. 2, April 2004.

an oil change annually, or every 100 to 250 hours, depending on the environment in which the unit will be located. The oil filter should be changed every time the oil is changed. Air filters need to be changed in accordance with the environment; diesel generators need a lot of clean air to operate properly and will suction collapse an air filter if it is allowed to get too dirty. It is recommended that you check the air filter every 100 hours and more frequently in dustier environments. Fuel filters should be changed every 200 to 250 hours depending on environment conditions and how clean the fuel is. "Generators should be exercised monthly at 30% of the nameplate rating or loaded to the minimum engine exhaust temperature recommended by the engine manufacturer."[14] Automatic transfer switches can be programmed to automatically start up and run the standby system at predetermined times.

Your standby power system will be a long-term investment if properly sized and designed to handle your facility or application load requirements. It is important to remember that a generator is a mechanical and electrical device that will require service and parts to maintain proper functioning. Understanding how your standby system operates, and dedicating time to maintenance today, will save your company the stress and cost of power problems in the future. When it comes to standby continuous power, there are two essential influences on the reliability of your company to stay operational: how well you know your particular system and how well you stick to a scheduled preventative maintenance plan.

[14] http://www.csemag.com/article/CA602440.html

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References:

Dembski, Darren. "Top Ten Reasons Why Generators Don't Start (And What You Can Do About Them)," presented at the Northern California Facilities Solutions for Engineering Engineer Show, September 21, 2006.

Johnstad, Kai and Matt LePard. *Essential Standby Generator System Requirements for Next Generation Data Centers*. White Paper #90, American Power Conversion, 2005.

Lane, Keith. "Power Quality and Generators – Part 7: Commissioning, Training and Long-Term O&M Programs." Seattle: Engineering, SASCO, 2005. <http://www.csemag.com/article/CA602440.html>

Norman, Tim. "Generator and Transfer Switch Maintenance." The University of Delaware: Applied Poultry Engineering News Vol.2 No. 2, April 2004.

http://www.batterystuff.com/tutorial_battery.html

http://www.ibsa.com/www/faqs/tech_talk/terms/s.htm