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Fuel Flow Equals Data Flow

Ensuring fuel reliability in Standby Generator Applications

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INTRODUCTION

Designing a standby power system for a data-intensive application requires not only the right generator for the load requirements but also the most reliable fuel available. Ultimately, it is the authority having jurisdiction (AHJ) that determines fuel reliability in any application. Understanding fuel reliability issues for standby power will allow you to work with the AHJ to select the right standby power system for the application.

Diesel fuel has been the traditional choice for standby power because its high thermal efficiency typically results in a lower cost per kilowatt in most applications. On-site fuel storage also ensures reliability. However, issues of fuel storage, contamination and breakdown can impact system reliability.

Gaseous fuels are being considered more often for standby applications because they avoid the fuel storage issues of diesel. The gaseous fuel infrastructure in most areas is generally reliable in an emergency, as well. However, local utilities can shut off the natural gas supply, especially during seismic activity, raising questions of reliability.

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Bi-fuel generators, which simultaneously burn both diesel and natural gas, effectively capitalize on the benefits of both diesel fuel and gaseous fuel while minimizing drawbacks that affect reliability. They offer the extended run times of natural gas, but can run on 100% diesel fuel if necessary. The amount of diesel fuel stored on site is significantly reduced, as well, because natural gas is the primary fuel. Other benefits include reduced maintenance costs, lower emissions and reduced capital costs.

You will likely design many standby generator applications to ensure the uninterrupted flow of data. Hardened data centers, for example, guarantee uptime for their customers, even in a catastrophe. Smartphone users expect their telecommunication providers to ensure 24/7 access to e-mail and the Internet, no matter the circumstances. Even large manufacturers sharing process information via SCADA require an uninterrupted supply of power to avoid costly downtime.

A key to ensuring reliability in backup power solutions for these applications is determining the most reliable fuel supply.

Reliability, however, can mean different things to different people. For example, some markets define reliability by the amount of run time required for the application. Both federal and local regulations have attempted to address this issue for certain markets, like healthcare.

In other cases, reliability means storing fuel on site, so that there is no question of its availability. On-site fuel storage, however, leads to questions of fuel quantity (how much is enough) and efficacy over long periods of time.

Ultimately, the final arbiter of reliability in a generator application is the authority having jurisdiction (AHJ). The AHJ is an organization, office or individual responsible for enforcing codes, standards or regulations1. The AHJ varies from place to place, and could include one or more departments of local or federal government. You must consult them as to whether the generator's fuel supply is considered a reliable one.

First, though, you should understand your fuel options as they relate to reliability in order to make the most appropriate power system recommendations and work most effectively with the AHJ

DIESEL FUEL: THE HISTORICAL FUEL OF CHOICE

You've likely specified many diesel-fueled generators. Indeed, they have been the traditional market norm for large-kilowatt standby power applications. Because of diesel fuel's high thermal efficiency, a diesel-fueled generator delivers a lower capital cost per kilowatt of electricity than a gaseous-fueled generator in applications of 150 kW or more. Diesel-fueled generators also provide your customers access to backup power if they do not have access to a gaseous-fuel infrastructure.

However, diesel may not always be considered the most reliable fuel. Issues of fuel storage, contamination and breakdown can impact reliability.

Consider storage, for example. As a general rule, diesel fuel can be stored for twelve months or more at an ambient temperature of 68°F (20°C), and an average of six to twelve months at a temperature of 86°F (30°C) or higher2, without significant degradation. As it ages, though, it will suffer the effects of oxidation, contamination by microorganisms and fuel tank corrosion3. Additionally, a diesel-fueled generator with a tank sized for 72 hours of full-load operation could easily take about 20 years to turn a single tank of fuel.

Then there is the issue of fuel breakdown due to oxidation. Oxidation occurs when the diesel fuel hydrocarbons react with oxygen to form a fine sediment and gum. If pulled into the engine, this could clog the fuel filter and fuel injectors, which will stop the engine from operating. You might even have to dismantle the entire fuel delivery system to address this problem. Additionally, the gum and sediments do not burn well in the engine, which could lead to carbon and soot deposits on injectors and other combustion surfaces. This might lead to a major—and likely premature—engine overhaul.

Water, which can enter the fuel system as condensation, promotes the growth of microorganisms like bacteria and fungi. These microorganisms feed on the fuel itself. If allowed to grow, they can form gelatinous colonies that can also clog fuel systems. They alsoexcrete additional water, and expel acidic waste that can lead to fuel tank corrosion. This corrosion in turn introduces metal alloys to the fuel, which are catalysts for oxidation. It is a regenerative cycle.

There are other conditions that can compromise diesel fuel as it ages:

- **Exposure to high temperatures.** This could occur by return fuel and normal exposure to ambient temperatures.
- **Exposure to dust and dirt.** These contaminants can contain trace elements of copper, iron, zinc or nickel that can cause the fuel to oxidize more quickly.

1 "Glossary," International Association of Certified Home Inspectors website, accessed October 4, 2010, http://www.nachi.org/glossary/a.htm? PHPSESSID=5fb066e0f5ff80e4d6f92e7ca73d7a84
2 BP Australia Limited. Long Term Storage of Diesel, accessed October 4, 2010, http://amsca.com/files/Download/Fuel_news_long_term_storage_diesel.pdf
3 O'Connor, Paul. "Recommended procedures for long-term storage of distillate fuels." Plant Engineering. 1984. accessmylibrary. (October 4, 2010). http://www.accessmylibrary.com/article-1G1-3527547/recommended-procedures-long-term.html
4 Assumes a 60% typical load level, weekly no-load exercising, and average power outages of only four hours per year

- **Fuel composition.** Some components in diesel fuel just naturally age quickly.

Bottom line—unless properly maintained, diesel fuel will lose its efficacy[4]. Before considering a diesel-fueled generator, talk to the AHJ to see if an ongoing fuel maintenance program will allow the generator to meet their reliability standards. If so, suggest a program to your customer that includes the removal of both water and dirt from the diesel tank. Water should be drained from the tank monthly—weekly in more active systems. Recommend that they keep the fuel tank full to reduce available oxygen and space for water to condense. Be aware, though, that this could present an additional challenge, as extended run times require more fuel storage. Some federal facilities are now requiring 96-hour run times. For very large tanks, see if your customer has other needs for the fuel. The NFPA 110 dedicated tank requirement could be upheld with demand-draw piping.

Availability of diesel for re-fueling in an emergency can also impact system reliability. According to the Edison Electric Institute, severe weather events account for 62% of unexpected power outages in the United States. These events can close roads and cripple municipal infrastructures, making it difficult or impossible to refuel the diesel generators used in standby applications. Talk with the AHJ to ensure that you size the fuel tank to address the aforementioned issues of fuel contamination or breakdown but avoid having too little fuel on-site and running out of fuel in an emergency.

Gaseous Fuel: Becoming More Popular

Gaseous-fueled generators are being considered more often for large-kilowatt standby generator applications. Technological innovations, such as optimization of engine speed (RPM) and integrated approaches to generator paralleling, are making gaseous-fueled generators both more powerful and more cost effective. Furthermore, gaseous fuels do not pose the kinds of environmental risks inherent in diesel fuel storage, and do not require ongoing maintenance. The improved emission profiles of spark-ignited over compression-ignited engines are also making gaseous-fueled generators more attractive to the ever-growing number of companies looking to reduce their overall carbon footprint.

Your concern, however, is fuel reliability. Let's look first at natural gas (methane). Generators fueled by natural gas avoid the reliability challenges faced by diesel fuel storage because the fuel is supplied by the natural gas infrastructure, which has proven to be extremely robust in many situations that cause power outages. Through four Florida hurricanes in 2004 and the Northeast grid failure of 2003, for example, the natural gas supply was unaffected.

Nevertheless, natural gas is delivered by a utility, and it can be shut off. This is more likely to occur in earthquake-prone areas, as all natural gas distribution lines are shut off during a seismic event. Talk to the AHJ to see whether the natural gas supply is considered reliable. If it is not, you can consider specifying a generator that runs on LP fuel, or runs in a dual-fuel configuration—with natural gas as the primary and LP as the secondary fuel. LP fuel can be stored on site for several years, more affordably and safely than diesel fuel, and without the need for routine maintenance.

One other issue to consider which might impact reliability—gaseous-fueled generators tend not to have the load response capabilities of diesel-fueled generators. This lack of response could cause the generator to produce oscillating voltage and frequency, which might cause problems with some loads. One such critical load is an uninterruptible power supply (UPS) system. A UPS system could have difficulty synchronizing to an oscillating voltage source. You can minimize this risk, however, by properly sizing the generator to the UPS system.

Bi-fuel Technology: The Best of Both Worlds

One way to alleviate the reliability challenges of diesel and gaseous fuel while building upon their strengths is to specify a system that burn both fuels at the same time within a single engine. Such is the case with bi-fuel technology.

A bi-fuel engine is a compression-ignited engine modified for simultaneous combustion of both diesel fuel and natural gas. Diesel fuel, which ignites at 500°–750°F (260°–399°C), is injected into the combustion chamber as a pilot fuel. The ignition of the diesel fuel in turn ignites the natural gas, which has a much higher ignition temperature of 1150°–1200°F (621°–649°C).

Bi-fuel generators start up using 100% diesel fuel. After certain criteria are met—such as acceptance of the electrical load—the generator's controller introduces natural gas to the fuel mixture. The controller slowly reduces diesel fuel injection while adding natural gas, until the unit is running more on natural gas than on diesel fuel. It is common to see fuel spreads of 75% natural gas to 25% diesel fuel. If the load increases, more diesel fuel will be added to increase engine RPMs and the natural gas will back off. Natural gas will once again be increased when the load stabilizes.

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Bi-fuel technology has been around for many years, but recent technology advancements have made it more reliable and efficient in power generation applications.

In most bi-fuel engine designs, the diesel fuel is introduced using existing injectors, while the natural gas is added through one of three proven techniques:

- Low pressure injection. Natural gas is injected via port injectors, so that it mixes with the air just before it enters the cylinder. This is done at moderate pressure—usually 50 psi or less. This approach requires installing individual natural gas fuel injectors onto the engine. Additionally, because many diesel engines use turbochargers to feed air into the engine, a gas compressor is required so that the natural gas injection pressure is higher than the boost pressure from the turbocharger. These extra components typically result in significantly higher costs.
- High pressure injection. The natural gas is delivered directly to the combustion chamber at the end of the compression stroke. This requires very high injection pressure—usually about 3000 psi. Because it requires a sophisticated—and costly—fuel delivery system, it is more commonly used in very large applications, such as municipal prime power.
- Combustion air gas integration. Sometimes referred to as fumigation, natural gas is introduced into the engine's air intake, right before the turbocharger, at a very low pressure—usually 5 psi or less. The turbocharger then ensures that there is a good air-to-gas mixture going into the combustion chamber. No engine modifications are required, so system costs are minimized. Additionally, advanced microprocessor, sensor and actuator technologies economically provide precise and responsive system control. This approach has seen the broadest application in the standby power market.

Bi-fuel generators capitalize on the reliability benefits of both diesel and gaseous fuel while minimizing their respective drawbacks. For example, generator running times are extended while on-site fuel storage requirements are decreased. This is because natural gas, not diesel, is the predominant fuel in a bi-fuel system. Assuming a typical fuel ratio of 75% natural gas to 25% diesel, you can spec a bi-fuel unit with a diesel tank sized for 24-hour continuous operation at full load and expect a running time of about seven days.

Additionally, because on-site fuel remains part of the system, reliability is improved. Should the natural gas supply fail—because it was shut off at the utility or was otherwise interrupted—the generator can run on 100% diesel.

Maintenance costs are reduced, as well. Testing has shown that bi-fuel engine oil remains cleaner compared to an engine running on straight diesel, thanks to the clean burning characteristics of natural gas. More importantly, though, the cost of diesel fuel maintenance is reduced because less fuel is stored on site.

Summary

Designing a standby power system for a data-intensive application requires not only the right generator for the load requirements but also the most reliable fuel available. Fortunately, you have several options at your disposal—diesel, gaseous and bi-fuel. You should understand the reliability issues of all these options before consulting with the AHJ to determine which fuel choice will best meet their definition of reliability while simultaneously meeting the needs of your customer.

AUTHOR BIO

Dan Barbersek is power solutions manager for Generac Power Systems, serving the eastern United States and Canada. With more than 25 years of experience in the energy industry as an application engineer—including 18 years in the UPS industry—he has a thorough knowledge of power technologies, from the conventional to the cutting edge. He has served in the United States Navy, where he completed Electrician's Mate "A" School, and is a member of IEEE, 7x24 User Group, EGSA and the North Carolina Healthcare Engineering Association.