GENERATOR RATINGS AND THE IMPLICATIONS FOR DATA CENTERS

By

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Understanding how generator ratings are determined is really very simple, but there is a long list of variables to consider. We'll review the basic fundamentals of generator ratings, but first we'll take a look at a recent industry discussion about specific ratings for generators in data centers and examine what's necessary for these facilities.

Recently, some generator manufacturers have created ratings specifically for products they supply to the data-center market. This is in direct response to the technical white paper "Data Center Site Infrastructure Tier Standard: Topology," published by the data center organization Uptime Institute LLC. The paper states that for Tier III (99.982 percent reliability) and Tier IV (99.995 percent reliability) designs of data centers, the generator, not the utility, is to be treated as the primary source of power. It is important to note that the references to Tier III and Tier IV designations have nothing to do with EPA Tier 3 and Tier 4 emissions requirements for engines (which we'll discuss later) – an unfortunate coincidence in designation that has led to a good deal of misunderstanding in the industry.

The Uptime Institute's paper specifies that the generator must be "capable of supporting the site load on a continuous basis" and refers to ISO 8528-1 (International Standard for Reciprocating Internal Combustion Engine-Driven Alternating Current Generating Sets), in which four generator ratings are defined: standby, prime, limited running time and continuous.

The result of the white paper is that data-center designers have specified generators with a "continuous" rating based on the peak demand of the site, which in turn has led to the installation of oversized generators that add unnecessary cost to the data-center design. We've even seen some generator manufacturers promoting and specifying a "continuous" rating for data center use on their generators in order to sell larger models and boost sales. At Kohler, we believe that oversizing of generators in the data-center industry adds unnecessary cost and diminishes efficiency. When you consider the actual runtime of these generators, oversizing does not provide value to the customer or improve reliability of the system.

Here's why specifying a continuous rating (as the Uptime Institute recommends) for generators in the data-center industry is unnecessary. First, consider that the main purpose of the ISO 8528-1 ratings standard is to classify the type of application for which a generator rating is to be used. In nearly every case, data centers are standby (emergency) applications. The generator is not the primary power source; it is used to back up a reliable utility, or in the case of Tier III and Tier IV data centers, multiple independent utilities. The only exceptions are areas where there are no utilities, and the generator is used as prime power.

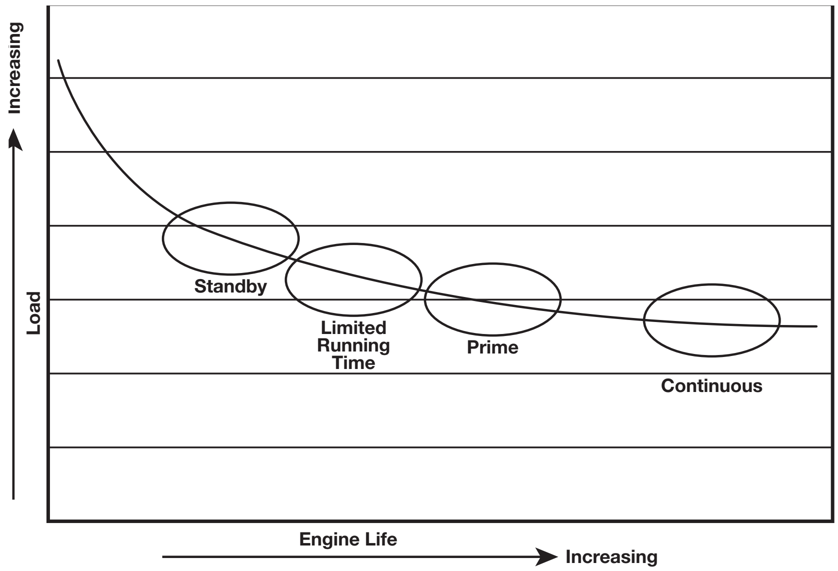

Figure 1
Load Level vs. Engine Life Relative to Rating

Figure 1 shows the relationship between the load level and engine life relative to the rating. The highest rating for a generator with a given engine and alternator combination is the standby rating; the lowest is the continuous rating. This relationship is the same for all engines (and generators). Although the slope of the line may differ from generator to generator, the relationship of these ratings remains the same. The more hours you plan to run the generator at a given load, the lower the rating needs to be to maintain the same level of reliability.

When choosing the generator rating, you need to know how many hours per year you expect the generator to be used and what the load profile looks like. As stated above, the majority of data centers are stationary emergency (standby) applications; generator runtime is low when backing up a utility. So even though the Uptime Institute specifies that the generator should be the primary power source for Tier III and Tier IV data centers, we know this is not the reality.

Another important factor to consider is the load profile over time. Figure 2 shows a standby application profile which has a varying load over time. Data centers have a varying load profile. In its white paper, the Uptime Institute provides generator rating definitions referenced to ISO 8528-1, which include a continuous rating. This does not consider the rest of the definition in ISO 8528-1, which states that the load is also non-varying. Figure 3 shows a continuous-rating load profile. Continuous ratings are intended for peak shaving programs where a designated block of power is sold back to the utility or used onsite, but are not intended for applications where the load varies. A data center's load profile is always variable, which fits the standby rating definition in ISO 8528-1.

REALITY CHECK

Consider a worst-case scenario. In 2005 Hurricane Katrina created an extremely long utility outage. According to the Energy Information Association, it took 30 days to resolve 90 percent of the utility outages after the hurricane. When you consider that a month of continuous generator run-time equals 720 hours and that the engines and alternators used in KOHLER® generators for large data-center applications are designed for tens of thousands of hours, a clearer picture starts to emerge. The fact is that standby-rated generators can run an unlimited number of hours with varying load during the utility outage.[1]

[1] Unlimited hours are subject to the manufacturer's recommended maintenance intervals.

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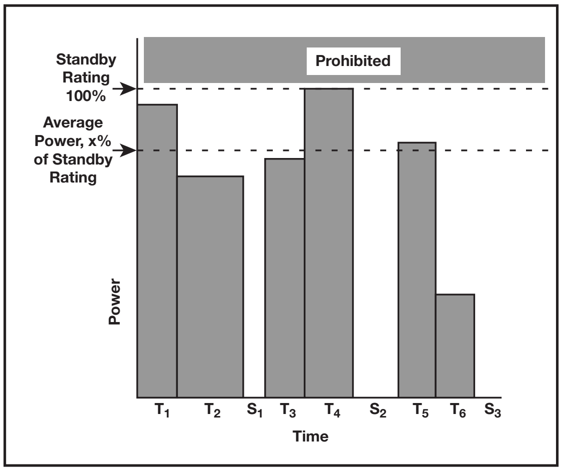

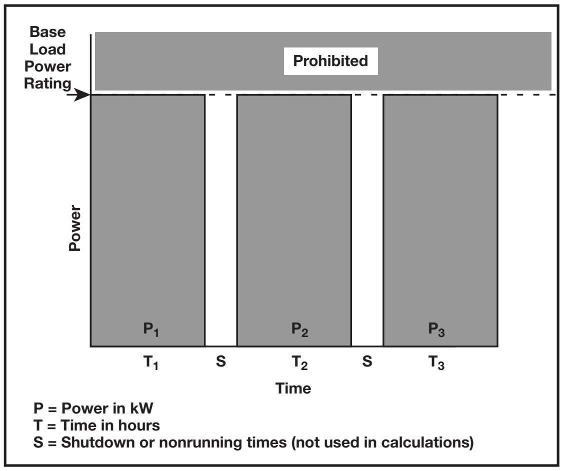

Figure 2
(pictured left)
Typical Standby Rating Load Profile

Figure 3
(pictured right)
Typical Continuous Rating Load Profile

Another point to remember is that the main causes of a generator's failure to start or to operate during an outage are not due to engine life, but to fuel contamination, low or dead starting batteries, or a poorly run maintenance program that did not follow the manufacturer's recommendations.

WHY ALL THE DIFFERENT DATA-CENTER RATINGS?

Some generator manufacturers offer multiple standby ratings definitions that vary based on the average load factor and number of hours run. ISO 8528-1 states that the average power output shall not exceed 70 percent power in a 24-hour period, unless the engine manufacturer agrees to a level higher than 70 percent. The engines in KOHLER® generators allow for an 85 percent average power level for large data-center applications. Thinking back to Figure 1, this is a true statement of an engine's durability. The generator can be specified using Kohler's generator-sizing program; all that is required is to enter the planned site load profile.

Given all of the above, our recommendation at Kohler is that data-center designers fully consider the actual requirements of the generator during an outage. Specifying the correct size generator at the start and then following a structured maintenance and testing program will prove the most sensible course of action.

Let's return to the rating of generators and look at the three major components that impact their rating and performance: Engine, Alternator and Cooling System.

GENERATOR RATINGS FUNDAMENTALS

The Engine

The component that impacts the generator rating most is the engine, because it is the actual power source. Every engine has a horsepower rating at a defined speed. Engine ratings are determined based on the application's load factor, site altitude and maximum ambient temperature during operation. The load factor is the percentage of engine power used over a given time period.

Altitude and ambient temperature extremes at the installation site can also affect engine performance. Each engine manufacturer will specify altitude and ambient temperature derates. A larger engine may be required for a high-altitude, high-ambient-temperature site (e.g., New Mexico) than one at sea level (e.g., Wisconsin). The generator manufacturer and its local representative will have engine-rating information for load factor and altitude and temperature derates.

The Alternator

The alternator converts the engine's mechanical power into electrical power. Therefore, the electrical power from the alternator is always a lower value than the engine's mechanical power; this is due to losses that occur in the conversion of mechanical power to electrical power. The level of loss is determined by the alternator efficiency. Alternator efficiency varies from manufacturer to manufacturer and from alternator to alternator.

Alternator design and construction is an important factor to consider for reliability. The durability of an alternator can be determined by looking at a few key design parameters governed by the National Electrical Manufacturers Association's Motors and Generators (NEMA MG 1) standard for alternators. The main attributes to look at are the alternator insulation class and temperature rise capabilities. Kohler, which has been manufacturing engine-driven alternators for more than 90 years, uses class H insulation, the highest insulation-class material available.

The Cooling System

Another important factor to consider in the sizing process is the generator cooling system. Most generator manufacturers offer 40°C (104°F) and/or 50°C (122°F) cooling systems. The peak temperatures the generator may experience in a year is a factor in selecting the cooling system. Even if you properly size the generator, failing to specify the right cooling system can lead to performance and durability problems.

IMPACT OF U.S. EPA EMISSION STANDARDS ON GENERATOR RATINGS

With the introduction of emission standards by the U.S. Environmental Protection Agency (EPA) for new stationary and non-road engines, the application of equipment must be considered when choosing a rating for generator sets installed in the United States. We must understand the EPA's newly introduced terminology in order to properly choose the generator rating.

A stationary "emergency" application is where the generator set remains in one location for 12 months or longer, is the secondary power source when the utility (primary power source) fails, and annual maintenance and readiness testing is less than 100 hours. The term "emergency" refers to the use of the engine when an emergency occurs (utility fails). In virtually all cases, these applications will have a "standby" generator rating. Remember that standby-rated generators can run an unlimited number of hours with varying load during the utility outage. Stationary emergency applications in the U.S. require diesel engines that are EPA-certified to Tier 3 if their power output is between 50 BHP (40 kW) and 560 BHP (500 kW), or certified to Tier 2 if their power output is above 560 BHP (500 kW).

A stationary "non-emergency" application is where the generator set is either the primary power source or a secondary power source connected to an unreliable utility with planned high hours of annual usage. Additionally, using it for peak shaving, interruptible rate, or any financial arrangement with a utility qualifies it as a non-emergency application. Non-emergency applications may use prime, limited running time or continuous ratings. Non-emergency applications in the U.S. require EPA-certified

Tier 4 diesel engines, which are designed for lower emissions and are much more expensive than their stationary emergency counterparts at the Tier 2 and Tier 3 levels.

A non-road application is where the generator set is in more than one location within a 12-month period. Typical applications are mobile, rental or containerized generator sets. Non-road applications may use prime, limited running time or continuous ratings. These applications require EPA-certified Tier 4 diesel engines.

CONCLUSION

There are many variables to consider when properly sizing generators, particularly when specifying for a data center. Choosing the proper generator requires an understanding of how the generator will be applied and what the site conditions will be. It is important to work with local or factory-based manufacturing representatives to properly size the generator for each application. Considering all of these factors will provide years of reliable power.

ABOUT THE AUTHOR

Todd Matte is the manager of the corporate accounts project management group at Kohler Power Systems. Matte joined Kohler in 1995 and has held multiple positions with the company including application engineering and product marketing roles. He has a bachelor's degree in electrical engineering from the University of Wisconsin-Milwaukee.

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