



How various loads affect the sizing of generator sets?

Electrical loads primarily fall into two categories, reactive and non-reactive. The difference in the loads are:

- ◆ **Non-reactive** - Non-reactive loads are purely resistive and include devices such as heater coils, filament lights, etc.
- ◆ **Reactive**
 - ◆ Reactive loads are devices that use an electrical coil with a magnetic field such as electric motors, solenoids, transformers etc.
 - ◆ Reactive loads can also be those including capacitors such as found in lighting balasters and UPS systems.
 - ◆ They are called reactive because they produce a reactive current when current flows through them. In a reactive load, the AC wave-form can have the current (A) intersecting zero behind voltage (V). The percentage lag is termed power factor (PF).
 - ◆ Three-phase generators are designed with a 0.8 PF where the current lags the voltage on the wave form and is 80% of voltage.
 - ◆ The inertia to overcome in starting an electric motor can have the current lagging the voltage by a higher percentage, with power factors around 0.4.

◆ Other Loads:

- ◆ **Peak loads** - loads that cycle on and off — such as welding equipment, medical imaging equipment, or motors cause Peak loads. Considering cyclic loads can significantly increase the size of the recommended generator set despite painstaking efforts to place loads in a step starting sequence.
- ◆ **Motor loads** - Calculating specific motor loads is best handled by sizing software, which will convert types of motors into load starting and running requirements. For this discussion, however, it is sufficient to broadly characterize loads as high-inertia or as low-inertia loads for the purpose of determining engine power needed to start and accelerate motor loads.

Low-inertia loads include fans and centrifugal blowers, rotary compressors, rotary and centrifugal pumps.

High-inertia loads include elevators, single- and multi-cylinder pumps, single- and multi-cylinder compressors, rock crushers, and conveyors.

◆ Motors over 50 HP:

- ◆ A high inrush current known as Locked Rotor Amperes (LRA) is needed to accelerate a motor from a dead stop, to its operating speed under load.

Full Load Amperes (FLA) is the normal running current that the motor will use at its maximum capacity. This is usually much lower than LRA.

For full voltage start, the LRA is about 7 times greater than the FLA.

- ◆ Locked Rotor Ampere (LRA), typically six to seven times the motor rated (running) current, causes generator voltage dip, which can affect other systems. The manner in which generator voltage recovers from this dip is a function of the relative sizes of the generator, the motor, engine power (kW capacity) and generator excitation forcing capability. Depending on the severity of the load, the generator should be sized to recover to rated voltage within a few seconds, if not cycles.
- ◆ Various types of reduced-voltage motor starters are available to reduce the starting kVA of a motor in applications where reduced motor torque is acceptable. Reducing motor starting kVA can reduce the voltage dip, the size of the generator set, and provide a softer mechanical start. However, these starting methods should only be applied to low-inertia motor loads unless it can be determined that the motor will produce adequate accelerating torque during starting.
- ◆ **Variable frequency drive (VFD) motors** - Variable frequency drives (or variable speed) are non-linear loads, which are used to control the speed of induction motors, induce distortion in generator output voltage. Larger alternators are required to prevent overheating due to the harmonic currents induced by the VFD and to lower system voltage distortion by lowering alternator reactance. For example, VFD loads on a generator must be less than approximately 50 percent of generator capacity to limit total harmonic



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distortion to less than 15 percent.

- ◆ **Uninterruptible power supply (UPS) loads** - A UPS system uses silicon controlled rectifiers or other static devices to convert AC voltage to DC voltage for charging storage batteries and are another type of non-linear load. Larger alternators are required to prevent overheating due to the harmonic currents induced by the rectifiers and to limit system voltage distortion by lowering alternator reactance.
 - ◆ Past problems of incompatibility between generator sets and static UPS devices lead to many misconceptions about sizing generator sets for this type of load.
 - ◆ Most UPS manufacturers have addressed these issues and it is now more cost effective to require UPS devices to be compatible with the generator set than to significantly oversize the generator for the UPS.
 - ◆ Use the full nameplate rating of the UPS for determining load to allow sufficient capacity for generator set battery charging and accommodating full UPS load capacity.
- ◆ **Battery charger loads** - A battery charger is a non-linear load requiring an oversized alternator based on the number of rectifiers (pulses)—up to 2.5 times the steady-state running load for three-pulse; to 1.15 times the steady-state running load for 12-pulse. These loads are typically found in telecommunications systems.
- ◆ **Medical imaging loads** - These include CAT scan, MRI, and X-ray equipment. The generator set should be sized to limit the voltage dip to 10 percent when the medical imaging equipment is operated with all other loads running in order to protect image quality.
- ◆ **Lighting loads** - In addition to lamp wattages, ballast wattages and starting and running power factors should be considered.
- ◆ **Regenerative loads** - For loads such as elevators, cranes and hoists, the power source is often relied upon for absorbing power during braking. That is usually not a problem when the utility is supplying power because it can be considered as an infinite power source with many loads. A generator set, in comparison, is able to absorb far less power, especially with no other loads connected. Generally, the regeneration problem can be solved by making sure there are other connected loads, which can absorb the regenerative power. Excessive regenerative load can cause a generator set to over-speed and shut down.
- ◆ **Future needs**
 - ◆ One last step in the sizing equation has to do with future needs. Power use is not fixed and tends to grow over time. Therefore, any generator set sizing exercise needs to consider system expansion. Even with sophisticated software solutions, the final decision on generator set size needs to be blended with judgment. And, the more you know about the parameters that affect sizing, the better that judgment will be.

For additional technical support, please contact ESL at customercare@eslpk.com