

Information Sheet # 07

Key Factors In Sizing Generator Set Systems

*Your Reliable Guide for
Generator Maintenance*

1.0 Introduction

All major generator set manufacturers provide sizing software with built-in formulas for calculating the load on a generator. The software will ask for required data to be keyed in for any particular application.

Correct loading of a generator is very important. Light loading can lead to wet stacking (See Information Sheet on wet stacking) and significantly shortened engine life. Engine manufacturers recommend engines do not run below 30% of full load for extended periods. But using a generator too small for the load can result in unacceptable voltage drops and overheating.

This information sheet details the factors that influence the sizing of a generator set and key load criteria a system designer should take into account.

2.0 Criteria should be considered when sizing a generator set system:

Voltage Dip - Various pieces of electrical equipment have different tolerances for voltage dip. (Manufacturer's specification sheets should be consulted for the allowable drop in input voltage). The starting load of electric motors can be six times running load. Starting loads can affect the generator's voltage regulator system by reducing the voltage available. Generators must be sized large enough to ensure the maximum allowable voltage drop to the system is not exceeded.

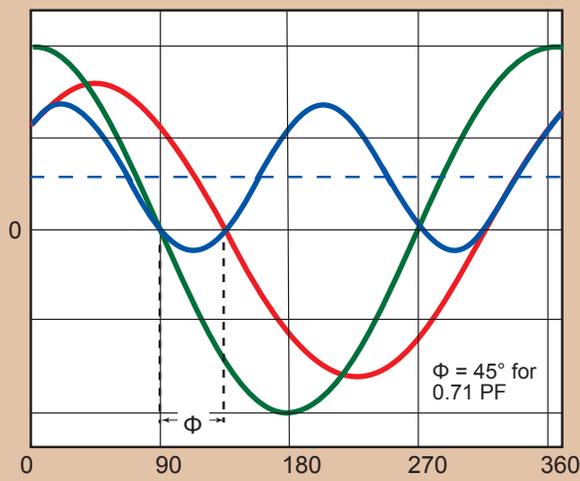
Frequency Dip - Generator sets produce a nominal frequency, which is 60Hz in North America. Excessive loads can overload an engine's governor system, reduce engine speed and hence generator frequency. The system designer has to take account of the maximum transient drop in speed and frequency the system will permit.

Ambients - An engine requires a certain quantity of air for combustion to achieve its rated power. Altitude, temperature and humidity will all affect the air density. An engine's power rating assumes an nominal altitude of less than 1000 feet, ambient temperature less than 85°F, and humidity less than 75%. Manufacturers detail the percentage reduction in available power for ambients conditions that exceed those assumed for the nominal rating (*Continued over*)

Check Chart for Determining Type/Size of Load to be Applied to the Generator

Criteria of Load	Load Category	Comments
Application	Standby	No overload capacity available for temporary power supply
	Prime Power	Generator set is primary power with 10% overload capability
Ambient	Altitude	Check manufacturer's derations (turbo-charger less than naturally aspirated)
	Ambient temperature	Over 85°F - check manufacturer's derate
Voltage Dip	Humidity	Up to a maximum of 6% but dependent on temperature
	Less than 25%	Less than 25%, standard AVR should maintain regulation
Frequency*	More than 25%	Above 25%, look at permanent magnet excitation generator
	Governor control	Verify maximum frequency dip the system will accept (*normally 60Hz in US)
Reactive Loading Electric Motors, etc	One Large Motor	Investigate sizing engine to generator and/or starting aids
	Several Electric Motors	Stage start with largest motor first
Non-reactive loads Lights, heaters, etc	Priority loads	These are the loads a generator set has to be sized for
	Non-essential loads	Consider if for standby, some loads could be dropped from standby circuit
Phase	3-Phase	Power factor will be 0.8 and requires a 3-phase generator
	Single Phase	See if single phase loads can be balanced on an 3-phase system
Voltage	Configuration	Star, Delta, Parallel, Zig Zag, etc
Electronic Loads	SCR loads	More than 25% SCR loading, may require larger sized generator end
UPS Systems	Leading Power Factor	Check with set manufacturer when UPS systems have leading power factors

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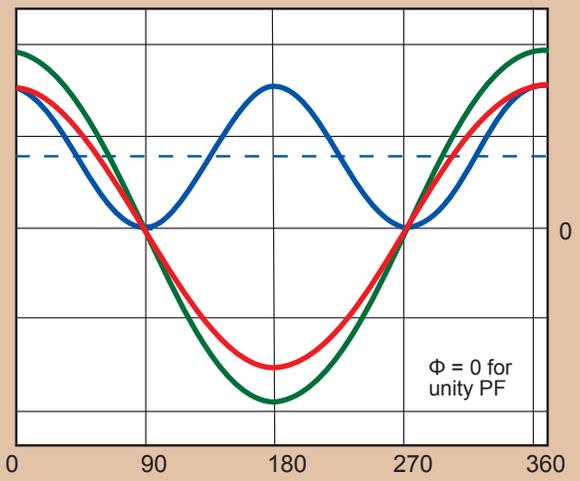


— Voltage
 — Power
 — Current
 - - Average Power

$\Phi = \text{Phase Angle}$
 $\text{PF} = \text{COS } \Phi$

$\Phi = 45^\circ$ for
 0.71 PF

Inductive load connected with current waveform lagging volts.
 Below unity PF only a percentage of the power is available at the load. i.e 0.8 PF has real power 80% of apparent power. Reactive loads have a percentage of power returned to the source.



Purely resistive load connected with volts and amps in step for an unity (1) power factor when all the source energy is transferred and available to the load. Good power factors are normally greater than 0.9 to 0.95.

(continued from page-one)

Application - Generator sets are rated for prime (continuous operation with 10% overload available for one hour in any 12 hours operation) and standby. Standby is an intermittent rating and assumes no overload capability. Standby ratings given by manufacturers can range 10% to 20% higher than prime ratings. Standby ratings assume the set will only have to run for a temporary period during main power interruption and are not for continuous operation or prime power.

3.0 Load characteristics that influence generator set sizing:

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 ballasters and UPS systems. They are called reactive because they produce a reactive current when current flows through them. In a reactive load, the AC waveform 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.

4.0 Power Factor and the influence it has on the sizing of generator sets for motor starting loads:

Power Factor - Power Factor (PF) in an AC circuit is the ratio between apparent power measured in volt-amperes and real power measured in watts. This difference is expressed as a percentage. For example, 0.8 PF equals 80%. Real power is the actual capacity of the electrical power source to power the equipment it is connected to. Apparent power is the product of the current and voltage within a circuit. Reactive loads such as inductors and capacitors have energy storage within the load producing a time difference between the current and voltage wave forms. (See diagram) The stored energy returns to the source and is not available to power the load, hence apparent power. An electrical system with a low power factor (less than 0.8) will require higher currents to deliver to the connected load a required quantity of real power than a system with a high power factor. Its important to note the utility company supplies their customers with volt-amperes, but charges them for watts.

To overcome inertia during the start period, starting kW can be six times running kW. Much lower starting power factors result in higher starting kVAs. The generator sizing program will calculate the kW for the engine to have sufficient horsepower and generator size to manage the higher starting kVA. If the load is just one large motor it may be necessary to determine the engine size and match it to a generator with a higher-rated starting kVA capacity.

5.0 Methods to reduce size of generator set to start electric motors:

The following methods can be used to minimize the size of set required.

Stage Starting - When there are numerous motors, the stage starting method calculates the size to start the largest motor first and then starts the other motors in a sequence within the kW/kVA capacity of the generator set.

Starting Aids - Transformer starting aids will switch the voltage through the starting cycle to manage the high starting kVA and reduce the overall size of generator set required. These aids are more common where there is just one motor.



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