Consultant's Corner: Generator Power Factor

consultants corner

Understanding power factor

Question: "If an AC generator is rated 480 volts and 900 amperes at 0.8 power factor, why can't the generator produce 480 volts and 900 amperes at 1.0 power factor?"

Answer: "It can, or can not, depending on how the generator set has been set up and rated. "How's that for an answer!

In reality, the generator is capable of producing 480 volts at 900 amperes, but the engine side of the unit is not sized to be able to deliver the horsepower (kW) to permit the generator to carry the load at the rated speed. Here's why:

Physics at work

Today's generators can produce electricity at 93.5 percent efficiency; the rest is lost in windage, bearing friction and heat losses. Further, 1 hp is equal to 0.746 kW of power which is equal to KVA times the power factor. These two considerations give us enough ammunition to figure horse power needed to produce a given kW.

For example a CAT 3412 gen set is rated at 600kW at 1800 rpm. The following engine horsepower is needed to deliver that power from a 93.5 percent efficient generator:

$$\frac{\text{600 kW output required}}{\text{.935 x 0.746}} + \text{20 fan hp} = \text{880 hp}$$

Note: This equation indicates that an 880 hp engine must drive the generator.
(This gives no consideration to overload capability.)

The 3412 gen set engine is factory set to provide 894 hp. So based on the formula presented, the CAT 3412 engine meets the horsepower needs to produce slightly over 600 kW.

The KVA is equal to the rated voltage and amperage multiplied by 1.732 divided by 1,000.
Therefore, the KVA for the above generator is:

$$\frac{\text{480 volts x 900 amperes x 1.732(constant)}}{\text{1000}} = \text{750 KVA}$$

Note: Because kW equals KVA times the power factory (0.8 lagging power factor is the NEMA standard) so the true output of this generator is 750KVA times 0.8 which equals 600kW.

Leading or lagging power factor?

Power factor can be leading or lagging, or in some cases, at unity.

A leading power factor can be caused by capacitor-intense loads, a lightly loaded synchronous motor or an induction motor that is being driven by its load. Lagging power factor is caused mainly by induction motors.

Unity power factor can be found in loads dominated by electronic devices or resistance loads such as lights and heaters

Average industrial loads include many motors, so the recognized standard is 0.8 lagging power factor. Leading power factor is practically unattainable with today's loads.

1. Any PF in excess of rated (greater than 0.8), the gen set output is limited by engine horsepower.
2. Any PF less than rated (0.8) output is limited by generator amperage.

Summary

Knowing exact load requirements assures proper equipment selection. A complete audit of the load profile will identify the power factor, helping you and Toromont to size the best unit for the application.
EPG Designer, an electronic gen set sizing program available through Toromont, can greatly simplify this process.