



Testing Gensets With Resistive Load Banks

Problem My 500kW genset, rated at 600volts, 601 amps, .8 PF, 3 phase, will not carry full load when tested on a load bank. Every time I get 600amps on it, the engine belches black smoke, chokes and the alternator trips off line. What's wrong?

Answer The engine was overloaded. The Genset actually was 125% load on it when it failed.

Reason We all know alternators are rated in kilowatts (kW's) right? *Yes, but...not really!*

Alternators are actually rated in Kilo-Volt-Amps (kVA)

When an alternator is made, like motors and transformers, the manufacture does not know where the alternator will be used, or what kind of load it will asked to supply power to. They can only rate the alternator based on how many amps it can supply at a given voltage, or Volt-Amps. Most alternators put out thousands of Volt-Amps, so we have the term kVA or thousands of Volt-Amps.

One customer may connect the genset to a motor load. Because of the coils in the motors, this is called an inductive load.

Another customer may connect the genset to an electric arc furnace. Because of the capacitance in that load, it is called a capacitive load.

Some customers may connect the genset to electric heaters and incandescent light bulbs. Because this load is really made up if resistors, this is called a resistive load.

The type of load the customer has the genset connected to can be any type or a mix of all three types. Each type, or mix, of load has a different effect on the relationship of the voltage and current that the load sees. Inductive loads cause the current to lag behind the voltage and capacitive loads cause the voltage to lag the current.

This lag is expressed at a number between zero and one. This number is known as Power Factor (PF). A PF of 1 means the voltage and current are in phase all the time and time and electrical work is being done 100% of the time. A PF of .5 means the voltage and current are in phase only half the time and electrical work is being done 50% of the time.



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Most of us think of power in kW's, not kVA. To help us understand the rating of alternators and motors manufactures do give us a kW rating. A kW rating is actually a mathematical calculation using the kVA and multiplying it by the PF of the load. Since the manufacture does not know your actual load power factor, they pick one. A normal power factor for most loads is around .8, so that's what manufactures use for calculating purposes. Therefore a 625kVA genset is also commonly referred to as a 500kW genset. The actual kW's a generator will produce, for a given amperage or load, is really controlled by the power factor of the customers load. It is worth mentioning that kVA is also known as "Apparent Power", or the amps and voltage produced by the alternator, and kW's refers to the "Real Power" being delivered to the load and thus carried by the engine.

Now lets talk a bit about the engine. We could say that the alternator carries the kVA load, because it has to provide all the amps and volts regardless of what type of load we are feeding. The engine only sees the kW load because it provides the muscle, or Horse Power (HP), only when electrical work is being done in the load. When we talk about engines driving alternators there is an old rule of thumb that still applies; "It takes 1½ HP to produce 1 kW". With that rule of thumb, it would take an engine with approximately 750HP to drive our 500kW alternator.

Here are the electrical formulas for kVA & kW. We will use these to calculate some loads on our genset.

Note: 1.732 is the square root of 3, a constant in all 3-phase calculations.

$$\text{kVA} = \frac{\text{Volts} \times \text{Amps} \times 1.732}{1000} \qquad \text{kW} = \frac{\text{Volts} \times \text{Amps} \times \text{Power Factor} \times 1.732}{1000}$$

Lets look at our 500kW genset producing full power at its rated .8 power factor and calculate both the kVA and the kW's.

$$\text{kVA} = \frac{600 \times 601 \times 1.732}{1000} \qquad \text{kW} = \frac{600 \times 601 \times .8 \times 1.732}{1000}$$

$$\text{kVA} = 625 \qquad \text{kW} = 500$$

Following the old rule of 1.5HP for 1 kW, when an engine is sized to go with this alternator and create a genset package, we use a 750HP (approx) engine.

So far, no surprises. This is all the same numbers you would see on the alternator nameplate. Now lets load bank the unit on a resistive loadbank, which has a Power Factor of 1 (or unity) and look at both the kVA and the kW's.

$$\text{kVA} = \frac{600 \times 601 \times 1.732}{1000} \qquad \text{kW} = \frac{600 \times 601 \times 1 \times 1.732}{1000}$$

$$\text{kVA} = 625 \qquad \text{kW} = 625$$

The kVA produced by the alternator did not change, because our amperage and voltage are the same, but look at the kW's we are trying to carry. We are now trying to get 625kW's from our genset. The alternator can handle it because it is not above its full kVA rating. The engine on the other hand is trying to carry the increased kW load, which now requires approximately 938HP to carry it. Our 750hp engine is now expected to carry about 125% load. ***It may not be able to!***

Reality Resistive loadbanks with cooling fans may actually have a Power Factor as low as .95, but we used 1 for easy calculations.

Caterpillar gensets do have reserve capacity built in. We expect to be called upon to carry short-term overload from time to time. Both the engine and alternator can handle moderate overloads for short durations.

No genset engine, if properly sized to provide cost-efficient operation, can be expected to carry up 125% of its normal load.

Points to Remember When testing your gensets on resistive loadbanks remember that your Power Factor will be near 1 or unity.

This will actually overload the engine if you attempt to carry the full nameplate current. Remember the kW rating on the alternator was calculated at a .8 PF, as indicated on the alternator nameplate. At a unity power factor, like on a resistive load bank, your kW load will be the same as your kVA rating on the unit. This condition will normally overload the engine.

Rule of thumb If you are loadbanking a genset on a resistive load, load the alternator to 80% of the nameplate amperage. This will put the engine at 100% load.