

Rated power factor tests and installation acceptance of emergency and standby power systems

> White paper

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This paper presents an explanation of the importance of testing generator sets at rated power factor. Typically, a generator set has a rating expressed in kW and power factor or kW and kVA. In order to check for proper operation of all emergency system support systems, it is important to test the generator at rated power factor or kVA. A generator operating at rated kW at 0.8 power factor lagging load requires more kW from the engine than when running at rated kW on a resistive load bank. This is due to a change in alternator efficiency and will result in increased operating temperatures and fuel consumption.

Cummins Power Generation recommends every generator set be tested at rated power factor either at the

factory or on-site during acceptance testing, but not necessarily both. Cummins tests production generator sets at rated load and power factor at the factory prior to shipment, hence, specifications need not require 0.8 PF testing of Cummins generator sets during on-site installation acceptance.

Our distributors are seeing an increasing number of specifications requiring on-site acceptance testing of the generator set at full rated load and power factor (rated kW and 0.8 power factor). These specifications are likely driven by generator set manufacturers who have not made the capital expenditure for reactive load banks and, therefore, cannot offer rated power factor testing as a factory service. NFPA 110, Standard for Emergency and Standby Power systems, allows the option of full load rated power factor testing either at the manufacturer's factory or during installation acceptance testing on site. If factory tested at rated power factor, then NFPA 110 permits on-site acceptance testing at unity power factor.

Cummins has made the investment in inductive load banks for production testing, because we do not want to use the customer's installation for our testing. Therefore, to avoid the higher costs and the problems associated with inductive load banks on-site, we encourage consulting engineers to require factory testing at rated load and power factor in their specifications. If rated load and power factor testing cannot be certified by the manufacturer, then the specifications must require on-site testing at rated power factor (using load banks to supplement facility loads as required).

Factory testing constitutes a necessary and adequate confirmation of the generator set capability to carry

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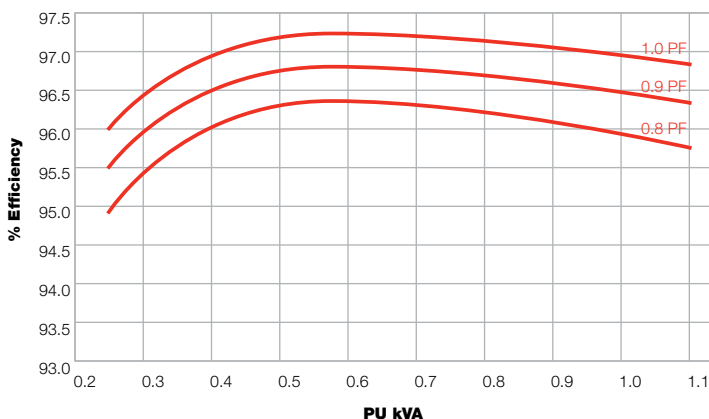


FIGURE 1

rated power factor load. Once demonstrated by factory testing, subsequent on-site testing at unity power factor is sufficient. Rated load and power factor testing is conducted to verify the following:

1. The engine must be capable of delivering the necessary power to the generator at rated power factor. Generator efficiency is a function of both load kW and load power factor and that efficiency can be a few percent lower at 0.8 power factor than at unity power factor as illustrated in Figure 1. This requires the engine to develop a few percent more kW at 0.8 power factor than at unity power factor.
2. A higher level of generator excitation (generator main field current) is required to maintain rated output voltage at 0.8 power factor than at unity power factor as illustrated in Figure 2. The generator produces a higher output current to support the kVA required by the load at 0.8 power

factor. The generator and all excitation system components (main generator, exciter and voltage regulator) must be tested to ascertain they are capable of operating at the higher current levels for extended operation at 0.8 power factor.

Cummins Power Generation endorses full load and rated power factor testing on every emergency and standby generator set as the only way to positively determine that each generator set is capable of supporting lagging power factor load when installed. However, installation acceptance testing should be performed according to the alternative outlined in NFPA 110. According to NFPA 110, paragraph 7.13.6 – 7.13.6.1 requires a full load test as follows:

“A load shall be applied for a two-hour, full load test. The building load shall be permitted to serve as part or all of the load, supplemented by a load bank of sufficient size to provide a load equal to 100 percent of the nameplate kW rating of the EPS (Emergency Power Supply), less applicable derating factors for site conditions.

A unity power factor shall be permitted for on-site testing, provided that rated load tests at rated power factor have been performed by the manufacturer of the EPS prior to shipment.”

The purpose of the field acceptance testing required by NFPA 110 is to confirm that the auxiliary support systems perform satisfactorily when the generator set operates at full load. These systems include fuel supply and delivery, intake air, exhaust air, ventilation and cooling systems. Usually there is not enough building load to allow the generator set to operate at full rated load and the building load must be supplemented by a load bank. This can be a fairly expensive proposition considering that most applications will require portable load banks to supplement on-site load.

If the generator set has been tested by the manufacturer at rated load and power factor prior to shipment, NFPA allows the field acceptance test to be run at generator set rated kW at unity power factor. NFPA recognizes that the site support systems are typically designed conservatively and that on site problems would be uncovered with rated kW load testing. Although it is true that the auxiliary support systems will be stressed slightly more when the generator set runs at lagging power factor, engineers need only specify field acceptance testing at unity power factor.

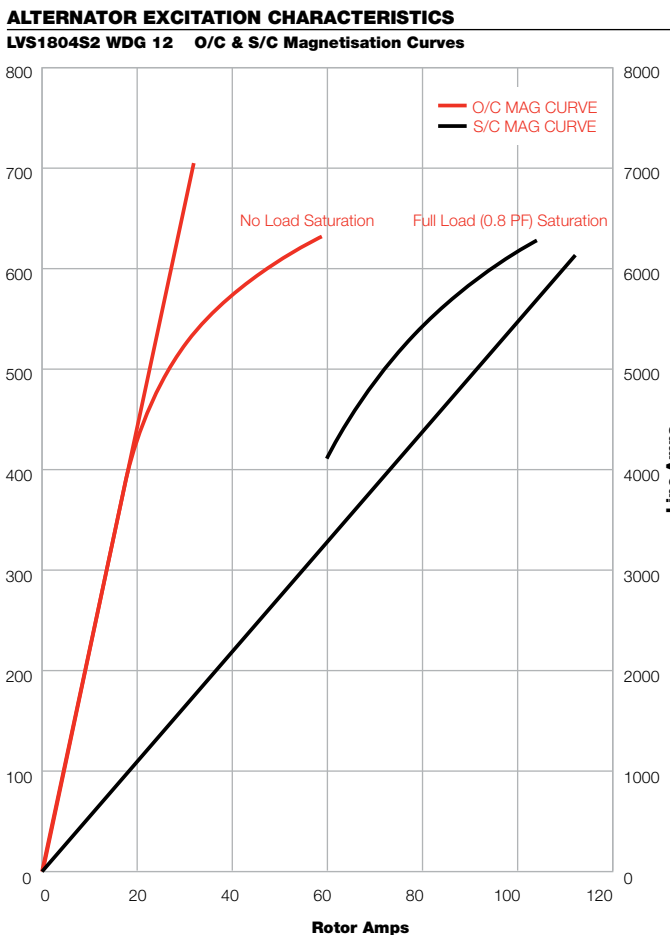


FIGURE 2

About the author



Jim Iverson is a senior applications engineer for Cummins Power Generation, with an M.S. in Engineering Science, and a B.S. in Electrical Engineering. Since 1976, he has managed Transfer Switch Design, Systems Engineering,

Switchgear & Controls, and Technical Marketing & Sales. Jim provides technical direction to Commercial Marketing & Sales, contributes to domestic industry codes and standards development, offers sales and service training, offers technical input for published literature and software, publishes technical papers on industry topics, and provides application engineering support to customers.

Summary

To verify full load generator operating characteristics, testing at full rated kW and power factor is required. Project specifications should include the specific reference to NFPA for full load testing. Generator manufacturers that conduct factory production testing at full load and rated power factor should be allowed to run the field acceptance tests at full rated load at unity power factor.

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