

Understanding Cummins Power Generation's suggested specifications for motor starting

> White paper

By Jim Iverson, Senior Applications Engineer



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Occasionally, consulting-specifying engineers using Cummins Power Generation's suggested motor starting performance specifications are challenged by a competitor and asked for relief on the specified motor starting kVA. This paper will help reduce confusion regarding the subject of generator performance recommendations when starting large motor loads.

Some competitors may argue that Cummins recommended specifications for motor starting constitute a "proprietary spec". Any supplier can provide a generator configuration that will meet the specifications that Cummins Power Generation recommends. Knowledgeable engineers generally understand our recommended specifications, accept them as good practice to avoid motor starting problems, and therefore hold all suppliers to them. Some competitors need to

increase their prices when they are forced to provide a configuration comparable to our standard products. While this can squeeze the engineer between competing suppliers, in the end it is the engineer's reputation that is maintained when motors start acceptably.

Explanation of motor starting specifications

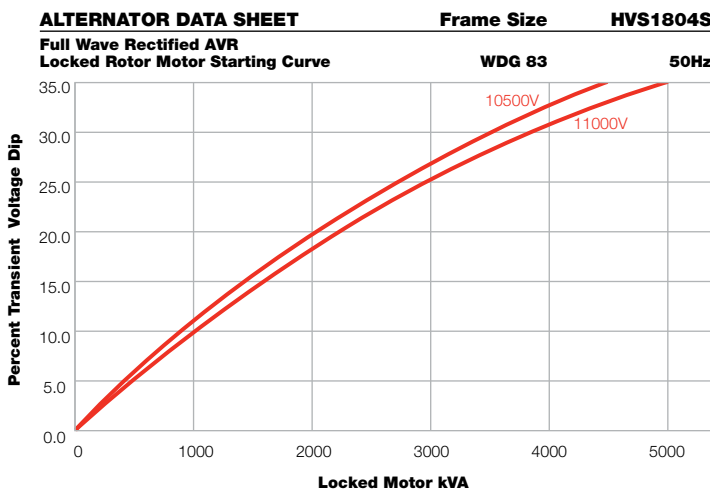
Cummins Power Generation's suggested motor starting performance specifications:

"Motor starting capability shall be a minimum of _____ kVA. The generator set shall be capable of recovering to a minimum of 90% of rated no load voltage following the application of the specified kVA load at near zero power factor.

Additionally, the maximum generator voltage dip on application of the largest single load step, _____ kW, _____ kVA, considering both alternator performance and engine speed changes, shall not exceed _____%."

When determining generator sizing recommendations, we consider what happens during the entire transient event. When a motor is first connected to the generator, an instantaneous voltage dip occurs which is strictly a function of alternator subtransient reactance, $x''d$, and the motor impedance. This corresponds to the dip shown on our published alternator data sheet, an example of which is included at the left.

The voltage dip curve represents a series of data points corresponding to the instantaneous dip that occurs before the excitation system reacts to recover the voltage. This data is gathered by testing the alternator on an infinite source. This dip will be greatly impacted by the alternator source impedance, a complex function of



National Electrical Manufacturers Association

NEMA is the leading trade association in the U.S. representing the interests of electroindustry manufacturers of products used in the generation, transmission and distribution, control, and end-use of electricity.

the electromechanical design of the alternator core and windings (steel materials and shapes, copper material and winding configuration).

After the excitation system responds during the next several cycles, the voltage is returned to rated, but following the characteristics and performance capabilities of the main alternator, exciter, engine, voltage regulator, motor and connected mechanical load response. The result may include a further drop in output voltage before recovery to rated voltage. The time required for all of these interacting dynamics will depend on generator capability and motor load requirements and all of the associated component time constants. This recovery time can range from fractions of a second to several seconds.

The instantaneous voltage dip is one key factor for motor starting applications. Instantaneous voltage dip must be limited to a magnitude and duration not disruptive to any generator connected load, including the motor starting equipment. Simple, predominantly motor load applications can generally withstand 35% dip or higher if the starter is mechanically held. The dip may be limited to lower magnitudes for a host of reasons including desire for conservative sizing, sensitive mechanical loads, code driven requirements (fire pumps, for example), fast acting undervoltage protection, other sensitive loads, particularly electronic loads where UPS equipment is not warranted and many other situations.

There are other considerations for generator set performance in motor starting applications including the engine load response that some competitors gloss over. It is key to note that alternator voltage dip curve information is not the only criteria. In fact, engine speed response to the KW load can cause under frequency protection incorporated in the excitation system to further reduce the output voltage during a transient event. This requires actual generator set transient test data be used as part of the sizing analysis.

Recommended industry practice

We advise engineers on several critical factors for sizing generator sets for many types of loads, including motors. Our expertise comes from ongoing research and testing, as well as listening to other expert advice such as NEMA (National Electrical Manufacturers Association), a trade association that most motor and generator manufacturers belong to or support.

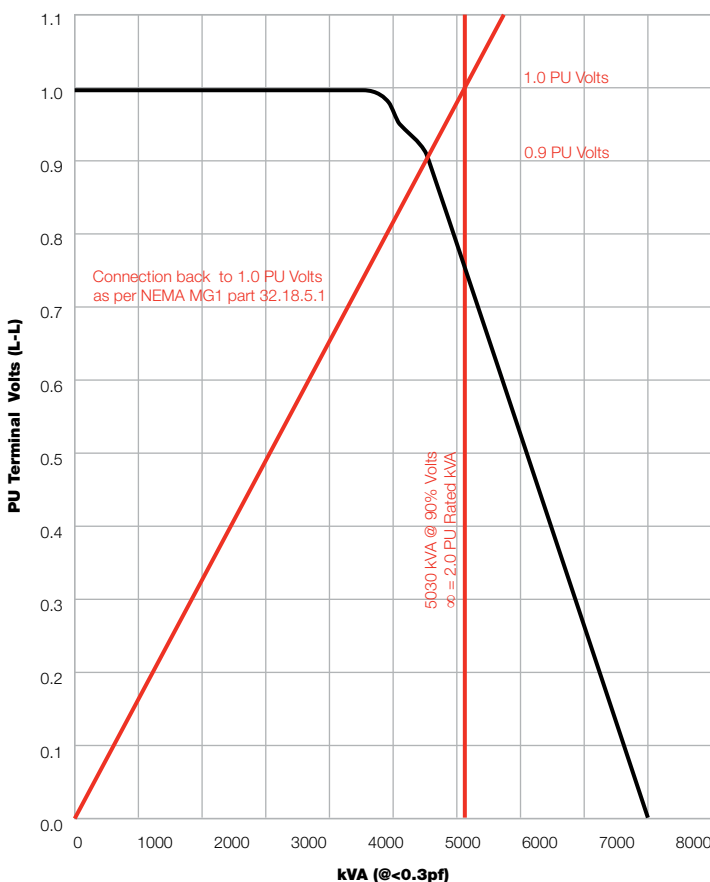
Although competitors have obviously read Cummins Power Generation literature and attempt to use it against us, they misconstrue our points. Cummins published maximum motor starting kVA ratings, are based on another important NEMA recommended industry practice for identifying the maximum motor starting (low power factor) kVA load that should be applied to a generator. NEMA requires the generator be able to recover to a minimum of 90% of rated output voltage with the specified load applied. Motor starting kVA can be determined

National Electrical Manufacturers Association MG1 Part 32 states:

“... the percent voltage dip versus kVA load curve should provide a voltage recovery to at least 90 percent of rated voltage. If the recovery voltage is less than 90 percent of rated voltage, a point on the voltage dip curve beyond which the voltage will not recover to should be identified”

by an examination of the alternator overload capability (or regulation) curve as shown below. The intersection

HVS1804S WDG83 OVERLOAD CHARACTERISTIC
 Generator rated at 2515kVA, 11kV 50Hz Class F



of 90% of rated voltage and the alternator overload curve represents the maximum kVA load at 90% rated voltage. Since motor locked rotor kVA is expressed at 100% applied voltage, the generator motor starting kVA is corrected to the same 100% base voltage (100% rated voltage). Graphically, you can see the derivation in the Overload Characteristic chart.

In the event the motor remains at stall during the initial transient period, as the generator voltage recovers, adequate accelerating torque is required by the motor to overcome the load torque and accelerate to running speed. If the generator can recover motor voltage to a minimum of 90% of rated voltage, the motor will develop 81% of rated torque, allowing adequate acceleration for most applications.

Requiring voltage recovery to a minimum of 90% of rated voltage at the specified maximum motor starting kVA is a practice Cummins Power Generation has followed successfully for many years. Motor starting kVA ratings are included in our product specifications and are applied as key criteria for generator sizing recommendations. Some competitors want to avoid being held to this specified performance and question the rationale. They attempt to make the point that the higher instantaneous voltage dip that occurs at the instant the motor is connected to the generator is the only thing that matters. To those points, the voltage dip during motor starting must not exceed the maximum allowable specified for all connected loads.

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.

Cummins generator recommendations are based on a combination of empirical and theoretical data. For motor starting applications, all of the following criteria need to be met:

1. Obviously, the generator must have enough power to run the motor load.
2. Upon application of the largest motor load step, the generator voltage and frequency dip must not exceed the specified maximum during the entire transient period.
3. With the largest motor load step applied to the generator, the generator must recover to a minimum of 90% of rated voltage.

Conclusion

Cummins Power Generation's suggested motor starting specification reflects our goal to manufacture generator sets that deliver all-around superior performance for our customers. Our specifications are based on solid engineering principles and accepted design criteria that any generator set manufacturer should be able to meet. By educating the engineering community and customers about generator set sizing and other application issues, Cummins Power Generation hopes to encourage them to include quantifiable performance requirements in their specifications. This will establish a level playing field for all generator manufacturers.

For additional technical support, please contact your local Cummins Power Generation distributor. They can be found at www.cumminspower.com.

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