The ultimate solution for maintaining your nationwide generator network

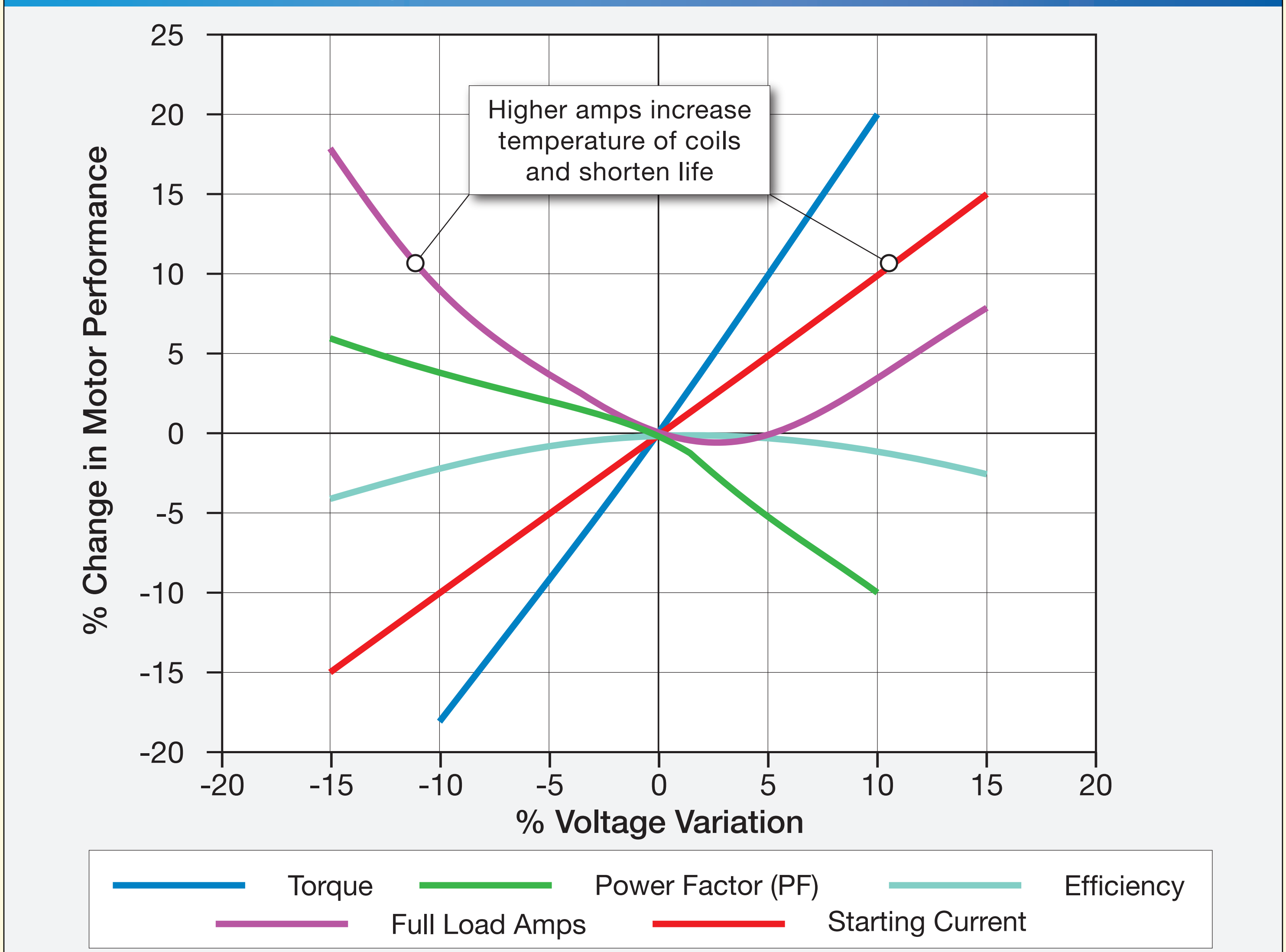
Automatic Voltage Regulators and the Need for Generator Voltage Stability

1.0 Introduction:

Equipment connected to the Utility Grid Network is designed to operate at a certain voltage for single- and three-phase connections. Connected equipment (loads) are defined as resistive (non-inductive), such as a heater, or inductive loads with electromagnetic coils, such as an electric motor or transformer. The Utility company is committed to supplying continuous electrical power maintained within certain frequency and voltage parameters. Connected loads do not perform as intended when their power supply exceeds their design limits for voltage and frequency. In many cases, under and over voltage has a detrimental effect on connected loads, particularly inductive loads. Standby generator systems must supply electrical power compatible with the grid; to do this, they employ an automatic voltage regulator (AVR).

This information sheet discusses the importance of stable voltage control, the effects on non and inductive loads, the dangers of brownouts, and the importance of an engine-driven generator system's AVR.

Graph -1 **Effects of ± Voltage Variation on an Electric Motor's Nameplate Ratings**



To fulfill our commitment to be the leading network service provider in the Power Generation Industry, the USA, Inc. team maintains up-to-date technology and information standards on Power Industry changes, regulations and trends. As a service, our **Information Sheets** are circulated on a regular basis, to existing and potential Power Customers to maintain awareness of changes and developments in engineering standards, electrical codes, and technology impacting the Power Generation Industry.

2.0 Categories of Connected Loads:

Nearly all devices connected to the Utility Electrical distribution network fall into two categories: non-inductive {non-reactive} and inductive {reactive} . The following describes how they differ and the importance of an engine driven generator system including an AVR:

2.1 Non-induction Loads:

Non-inductive loads are referred to as resistive loads. A resistive load consumes only active power (non-reactive). In electrical terms, they are simple loads, and when connected to an AC circuit, the current (amp) and voltage sine waves are in phase with each other. These loads resist the current as in heater coils and incandescent lighting.

2.2 Induction Loads:

Inductive loads (reactive) are frequently termed electromagnetic loads. (*See information sheet Generator 101 Part 2*)
When the coils of an electromagnetic load are energized by an AC power source, a secondary voltage is induced, termed a reactive current. These loads include electric motors, transformers, and solenoids. Due to the reaction, the current in these circuits lags voltage by 90 degrees

It is very important to have a stable input voltage to an inductive load. As Power is a function of Amps (I) and Volts (V), reduced voltage can increase the amps and overheat the device. For this reason, generator systems require an AVR to maintain a steady output voltage.

3.0 Definition of an AVR on an Engine Driven Generator System:

An AVR is an electronic device fitted to the alternator (electrical generator driven by the engine) to maintain voltage output within a predefined range (either single or three phases) through all loads from zero to total capacity. The voltage variation level depends on the type of AVR and the specifications of the connected load.

4.0 Problems that Occur With Unregulated Voltage Output:

Reactive and non-reactive loads can be adversely affected by high and under voltage, effects include:

- Motor efficiency drops for both high and low voltage input.
- Incandescent lights will burn brighter with higher volts, which can shorten the life of the light.
- Electronic devices operating on DC can be adversely affected if the AC/DC adapter input volts are not to specification.
- Power Factor will drop sharply with higher volts. (*See information sheet on Power Factors*)
- While low volts will increase the current to an electromagnetic device, high voltage to an electric motor can result in the magnetic portion of the motor going into saturation.

5.0 The Effects of Low and High Voltage on an Electric Motor:

A typical load for an engine-driven generator system is an AC motor driving through its shaft, a piece of equipment for many industrial, commercial, and residential applications. The input power to a motor (which translates to the shaft power to the connected piece of equipment) is a function of amps times volts. If the input volts vary, the amps drawn will change; the adverse effect will depend on the degree of change within the designed ratings of the motor. The following summarizes the impact of high and low voltage on an electric motor:

5.1 Effect of Low Voltage:

When the motor's input voltage falls below its rated voltage, the connected load pulls the same power, resulting in greater current (amps). If the voltage drop creates a higher current than the motor windings are rated for, heat will build up in the motor and, over time, lead to failure. Not only is the motor lost, but also the impact losses of the connected equipment failure

5.2 Effect of High Voltage:

High voltage can be as negative as low voltage. As an electromagnetic device, a high voltage input to an electric motor can push the magnetic portion of the motor into saturation. This results in the motor drawing more current to magnetize the iron beyond the level where magnetizing is practical.

5.3 Susceptibility of Various Motors to Input Voltage Outside Ratings

See Graph -1, which graphically depicts the torsional effects on an electric motor when the voltage drops:

- Small motors are more prone to damage from over voltage than larger motors.
- Single-phase motors are more susceptible than three-phase motors.
- U-frame motors are less sensitive to over voltage than are T-frames.
- Power factor improves with lower voltage and drops sharply with higher voltage.
- Inrush current goes up with higher voltage.
- Efficiency drops with either high or low voltage.
- Even lightly loaded motors can suffer from a drop in input voltage.

6.0 Definition of Brownouts and Why they Have to Be Avoided:

A Brownout is when the utility company deliberately lowers its output voltage. Unlike a Blackout, when the utility power is completely shut down in a given area of the electrical distribution system, in a Brownout, when the Utility is trying to meet capacity, they can come up against a temporary reduction in system voltage or total system capacity.

6.1 What Should Electrical Power Users Do in a Brownout:

While some electronic equipment manages Brownouts, electromagnetic devices, including air conditioners and electric motors (industrial/domestic equipment such as fans, dryers, freezers, factory processes, and elevators) would experience the adverse effects of prolonged low voltage outside their nameplate rating and should be shut down, or switch to standby power.

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