Your Premium Provider for Supply and Service of Electric Motors, Industrial Controls, and Power Distribution Solutions

LAYCO ELECTRIC INNOVATIONS

Information Sheet # 11

Your Reliable Guide for Power Solutions

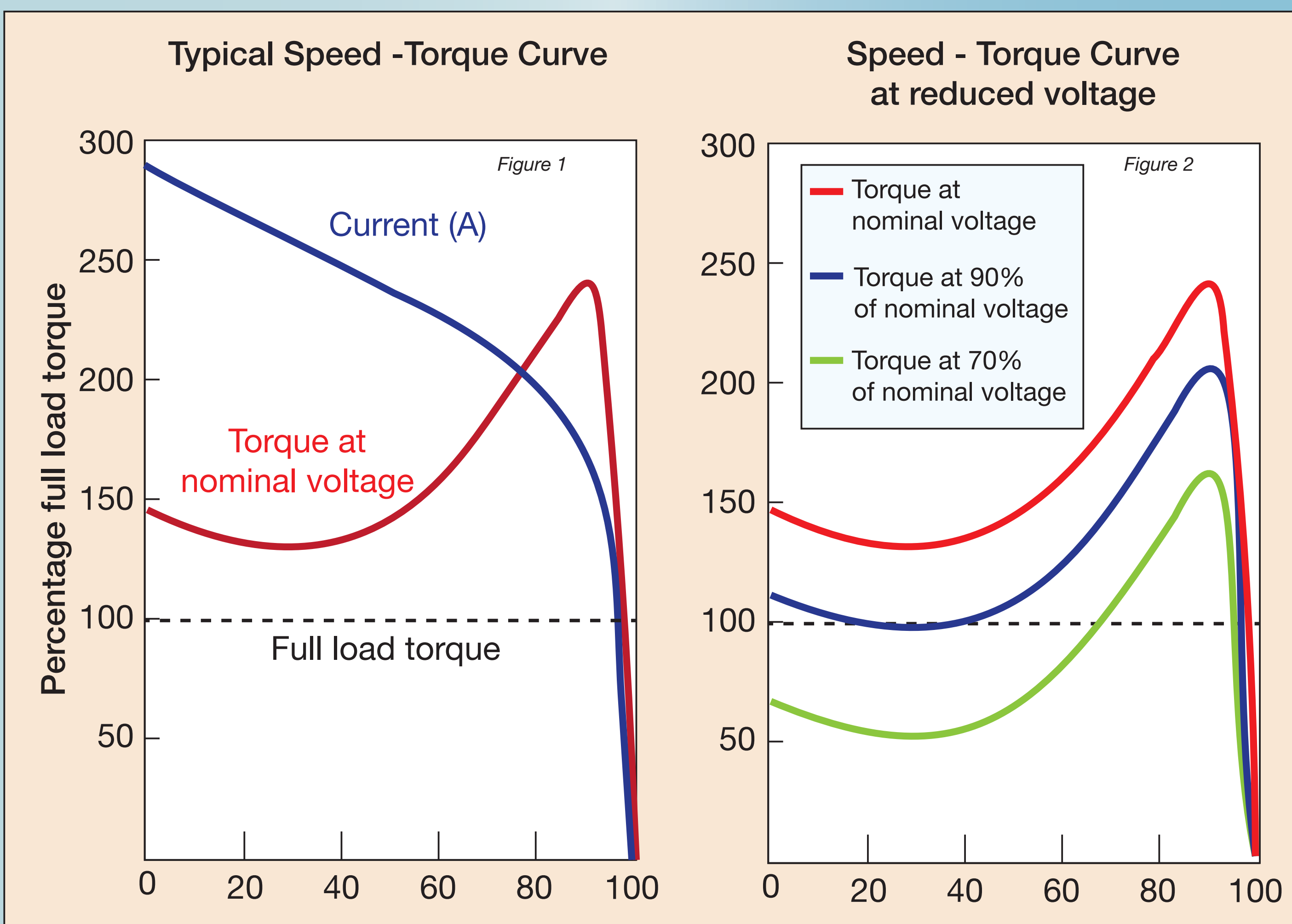
BROWNOUTS & THE ADVERSE EFFECT
On Electric Induction Motors

1.0 Introduction:

Primarily when considering the reliability of electric power from the utility system, the first concern is a complete power outage referred to as a “Blackout”, but there is another potentially equally damaging scenario to connected electrical equipment termed a “Brownout”. A Brownout is different than a Blackout. In a Brownout, the voltage provided by the power supply drops below its standard value, but the electric service is not interrupted completely. A Brownout is defined as a period of reduced voltage of electric utility power, particularly in periods of high demand on the utility supply, that results in reduced illumination.

This information sheet discusses the adverse effect brownouts have on electric motors, particularly induction motors and how to manage them.

The Effect of Voltage Drop (Brownout) on Electric Motor Torque



To fulfill our commitment to be the leading supplier, the Layco Electric Innovations team ensures they are always up-to-date with the current industry standards as well as industry trends. As a service, our **Information Sheets** are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power and motor control industry.

2.0 What Causes Brownouts?:

Brownouts can be created intentionally by the utility power supply to manage a load reduction in an emergency and to avoid going to a full blackout. The power company tries to avoid brownouts due to the potential adverse effects on various connected loads.

More frequently brownouts are unintentional due to unforeseen loads on the utility supply, for example:

2.1 Unusually High Power Demand – Very high ambients in the summer will cause much greater loads as air-conditioners run continuous with the sum average of all connected utility customers above the capacity of the utility supply. Similarly, very cold winters result in total connected heater devices placing an above average power demand.

2.2 Parts of the Utility System Going Off-Line – Utility companies have multiple sources of power generation, and various ways to route power to their customers. The utility usually supplies power below full capacity of all the power generation centers feeding the supply, for example the utility, or grid system, may only be loaded to 80% of capacity with surplus power available to meet seasonal variations. However, should part of the system go off-line a greater load is placed on the remaining power supply. Failure of power capacity could be maintenance planned shutdowns, unplanned failures, and switching issues.

2.3 Distribution Grid Network – An electrical grid supply routes power to users through a complex network with the grid having connections to numerous power supplies; coal, gas, nuclear, hydro, renewable, etc. The grid system is designed to switch power to users from various supply sources. Should one supply go off-line the power to connected customers will be automatically fed from another source. When there are issues with the grid supply; lighting strikes on transformers, wind damage, switching system issues, etc., the remaining grid can end up being overloaded.

3.0 What is Considered Low Input Voltage Input to an Electric Motor:

Undervoltage is defined as a condition where the applied voltage drops to 90% of rated voltage, or less, for at least 1 minute. Low-voltage conditions occur when a facility asks for more power than the line can deliver. However the root cause of low utility voltage could also be a transformer having an inadequate capacity restricting how much total utility power gets through to the motor.

4.0 Adverse Effect of Low Input Voltage on a Electric Motor:

For an electric motor the torque changes as the square of the voltage applied - see *figure 1*.

Therefore, with a 10% increase in voltage the square 1.1 x 1.1. = 1.21 (a 21% increase in torque).

However, inversely when rated voltage drops 10% , the square 0.9 x 0.9. = 0.81 with the motor experiencing a 19% reduction in torque .

A greater undervoltage condition of 20% below rated value the square 0.8 x 0.8. = 0.64 reducing the motors torque to only 64% of rating and a 156% overload condition that can result in a catastrophic failure - see *figure 2*.

4.1 Adverse Effect On Motor – The electric motor usually stalls when the torque decreases below the required torque of the connected load. When stalled, the electric current flowing in the coils no longer produces mechanical energy, just heat. In effect, a 100-hp motor in a locked rotor state will become a 500 kW resistive heater.

4.2 Effects Of Heat On Motor – Designers of electric motors are always conscious of the effects of heat on the insulation. The motors are designed with sufficient cooling and ventilation to disperse the heat generated at rated voltages and full loading. Increased heat generated by a drop in voltage input, but no fall in connected load, will lower the life of the insulation.

Insulation life can be halved for every 10°C rise in temperature. However, with a 10% drop in voltage winding temperature will rise between 10°C and 15°C for each 10% drop in voltage. Therefore the insulation life the motor was designed to have when operating at rated voltage will fall by 50% to 75% of expected design life.

Brownouts that result in much greater drops than 10% of voltage will have a devastating effect on winding insulation resulting in failure of the motor. If a system has multiple motors connected during a brownout with more than a 10% drop in voltage all will experience damage to their insulation. The only motors that will escape damage are those that are shut down.

5.0 How to Protect Electric Motors from Brownouts:

In many systems the magnetic contactor for turning the motors on and off includes a coil and acts as a solenoid. It is not advisable to rely on this contactor during brownouts because repeated de-energizing of the coils creates chatter, explained as repeated “make and break.” Turning a motor on and off at that rate will damage it because its equivalent to starting it 1½ times rated voltage.

5.1 Controllers Programmed to Respond to Reduced Voltage – A Programmable Logic Controller (PLC) is an electric motor controller that can be programmed to control the response of the motor to many varied inputs, including low voltage input. PLCs monitor the power quality and manage situations of low voltage and unbalanced loads.

When a power quality survey determines most system undervoltage events are shorter than 30 seconds, the PLC can be programmed to ignore events less than 40 seconds in length, or any other defined number. As NEMA MG1 says a 2% voltage unbalance means the motor should be down rated to 90% of rated horsepower, you can program the controller to do so when it detects a 2% voltage unbalance.

5.2 Check With the Utility – If a facility with many electric motors is repeatedly being subjected to low voltage events, the quality of power to that facility may be reduced due to the power supplied to another utility customer. The Utility should update their substation to ensure other customers are not being adversely affected by one customer that is overloading the line.

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