The Effects Of High Or Low Voltage On The Performance Of A Motor

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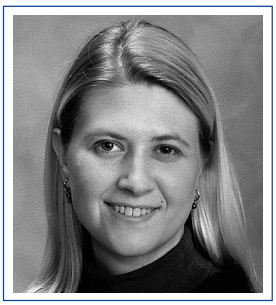


NEMA MG-1-12.45 states that motors shall operate successfully under running conditions at rated load with a variation in the voltage or the frequency up to the following:

a. Plus or minus 10 percent of rated voltage, with rated frequency.
b. Plus or minus 5 percent of rated frequency, with rated voltage.
c. A combined variation in voltage and frequency of 10 percent (sum of total values) of the rated values, provided the frequency variation does not exceed plus or minus 5 percent of rated frequency.

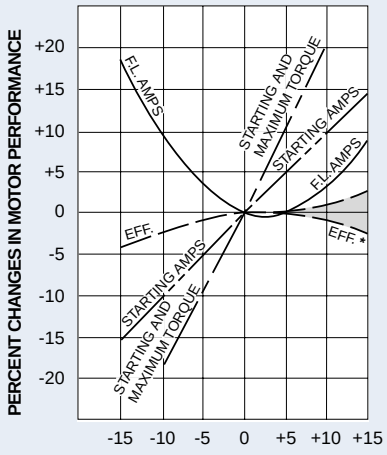
There is usually no problem with frequency variation, unless we get into operating at 50 Hz, but that would be an article all by itself, so the focus here will be on voltage variation only. Even though NEMA states that motors are designed to operate within 10 percent of rated voltage, that doesn't give an accurate picture of what will happen when a motor is operated with high or low voltage. Any change from the rated voltage and frequency will affect the performance of the motor, sometimes dramatically.

Today's standard T-frame motors are designed with high flux densities and therefore are more susceptible to improper voltage conditions that will affect performance.

Older motors and high efficiency motors are designed with lower flux densities, so any variation from the rated voltage will not affect the performance as much (but it may still have negative effects!).

Higher voltage equals higher flux, so in some situations, high voltage can actually improve the performance, but at some point the core will begin to saturate and heat up quickly.

Having a low voltage supply is more dangerous than high voltage, because as less voltage is applied, there is less flux in the iron. Less flux means the core iron is not being used to its optimal level, so efficiency and torque start to fall.



*** Note:** Efficiency may increase or decrease depending upon motor design.

This chart shows a summary of the typical effects of high and low voltage on the performance of a motor. When rewinding a motor that you know does not match the customer s voltage supply, consider changing the design slightly to meet the exact voltage requirements. This will ensure that the motor will perform at its optimal level.

More often than not, your customer will have a high voltage supply, but there are cases where it may be low. For example, you could have a motor designed for 440v, but the power supply is actually 485v or 490v, which is right on the edge of 10 percent over voltage. Or you could have a motor designed for 230v, and the power supply is only 208v, right on the edge of 10 percent under voltage.

The following is a summary of the effects of over and under voltage for typical induction motors:

Torque

The torque of an induction motor varies as the square of the voltage, so any small variation in voltage will significantly affect the starting and maximum torque. At 110 percent voltage, torque will increase by 21 percent, but at 90 percent voltage, the torque will decrease by 19 percent. This could be a problem if the motor needs to start a high inertia load.

Speed

The speed of a motor is going to change slightly with high or low voltage. At 110 percent voltage,

Effects Of Voltage . . . Continued

the speed will increase about 1 percent, and at 90 percent voltage it will decrease about 1.5 percent. But when you look at the speed change in percent slip, the numbers are more dramatic. At 110 percent voltage, the percent slip will decrease by 17 percent, but at 90 percent voltage, the slip will increase by 23 percent.

Efficiency

At 110 percent voltage, the efficiency of a motor may actually increase up to 1 percent. However, at 90 percent voltage, the efficiency is going to decrease about 2 percent. This will especially be a factor to consider for larger motors because of the cost of a lower efficiency.

Current

The starting and full load current will also be affected by changes in voltage. At 110 percent voltage, the starting current will go up 10-12 percent, but the full load current will go down 7 percent. This would be a problem if the power supply cannot handle the higher starting current. At 90 percent voltage, the starting current will decrease 10-12 percent, while the full load current will increase 11 percent.

Temperature Rise

The temperature rise at full load will be somewhat affected by variations in voltage. At 110 percent voltage, the temperature rise will decrease 3-4°C, unless the core has become saturated (the temperature would increase). At 90 percent voltage, the temperature rise is going to increase 6-7°C. A general rule is that for every 10°C increase in total temperature rise, the insulation life will be cut in half. Even a slight under-voltage is going to increase the temperature, so that can make a difference in the insulation life of the motor.

Overload Capacity

At 110 percent voltage, the motor will actually have a 21 percent higher overload capacity, but at 90 percent, the capacity will decrease by 19 percent. More often than not, a motor is going to be overloaded for some period of time, so if the motor is operating with under-voltage, the possibility of failure increases.