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Monthly Informative Application Guidelines, with respect to *Motors & Drives* to keep you better INFORMED.

APPLICATION GUIDELINE #10

(Overspeeds)

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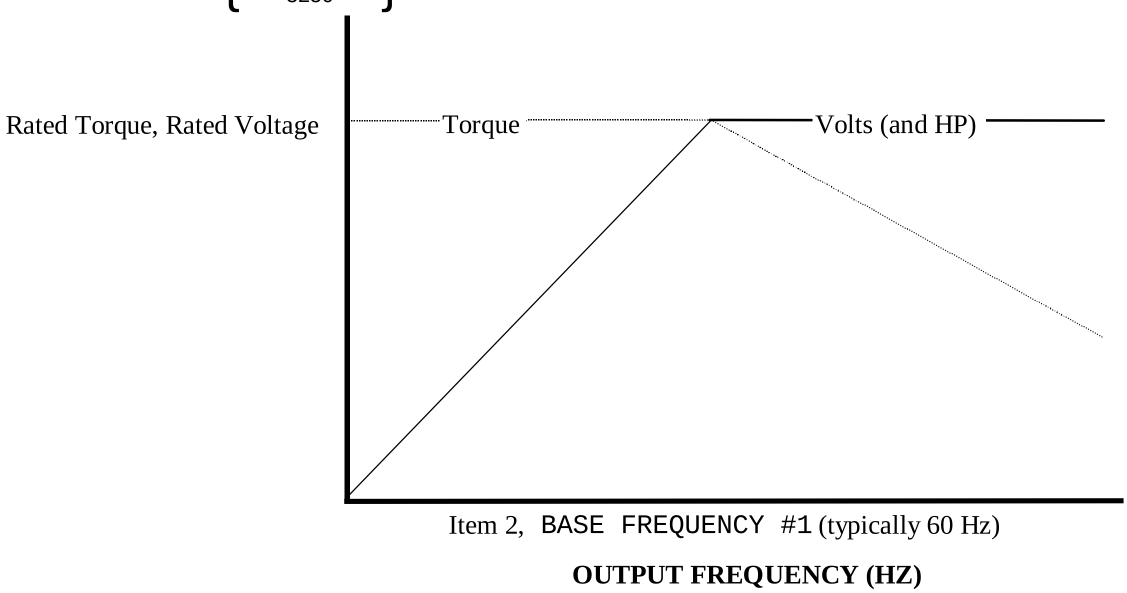
Variable frequency Drives (VFD's) are used for two purposes, process control and energy savings, I often refer to a third reason which would be for obtaining an unlimited number of starts and stops without harmful effects to the motor. The first of these two purposes is 'process control', this refers to having infinite speed control over the motor to either slow it down for greater control or to speed it up for increased production. The second purpose for VFD's is for 'energy savings', which can be realized when applied to variable torque loads such as centrifugal fans and pumps, whose torque is dependent upon speed (proportional to the square of the speed, 90% speed = $(0.90)^2$ = 84% Torque).

In overspeed situations, available Torque from motor/drive systems becomes a big issue. **First of all**, the VFD can only output as much voltage as is available at the input, maximum voltage usually is set to 60Hz, thus as the frequency increases above 60Hz, there is no more available voltage to maintain constant Torque. As the speed increases above 60Hz, torque decreases, therefore Hp remains constant, $Hp=\left\{\frac{\text{torque x speed}}{5250}\right\}$.



The above volts/Hz relationship could lead one to estimate torque available in overspeed by an inverse relation. For instance to estimate continuous torque at 90 Hz,

$$T_{90} = T_{60} \text{ X } (60/90) = 67\% \, T_{60}$$

A 3 HP 575 volt G3 was used to run a 3 HP TEFC 4 pole EQP3 at 60, 90, 120, and 150 Hz. At rated motor current, the following maximum *temporary* torques were developed:

Hz	Actual % Full-Load Torque	Predicted % Full-Load Torque
60	182	100
90	97	67
120	56	50
150	**36**	40

Secondly, as motor RPM increases:

- The torque required to overcome bearing friction increases at the same rate.
- The torque required to move the motor's fan increases as the square of the speed change.
- Above 60 Hz, the motor's breakdown (maximum) torque decreases as the square of the speed change.
- The motor's inductive reactance (impedance) increases at the same rate the frequency increases. As the impedance increases, the current decreases (because more voltage isn't available), thereby decreasing the available torque.

For this particular motor, at 150 Hz it appears that the breakdown torque (which decreases as the square of speed increase) has "crossed" over the full-load torque and is now the limiting factor for torque development.

Recommendations

- On applications requiring output frequencies up to 90 Hz, derate the motor's rated full-load torque by the ratio of base frequency to maximum operating frequency
- On applications requiring output frequencies greater than 90 Hz, derate the motor's full-load torque by the square of the ratio of base frequency to maximum operating frequency.
- Check with motor manufacturer concerning overspeed operation. Rotor balance and bearing life (including limiting bearing speed) are of concern when over-speeding a motor.

There are some applications that are suited to over-speeding of a motor. The benefit of using, for example a 1200RPM motor on an 1800RPM application, is that a 1200RPM motor produces more low speed torque for the same amount of current or same sized drive, which is demonstrated by the following common formula:

$$\text{Torqe}=\left\{\frac{\text{Hp x 5250}}{\text{speed}}\right\}.$$

$$\text{Torqe(50Hp,1800rpm)}=\left\{\frac{50 \text{ x } 5250}{1771}\right\}=148 \text{ lbft}$$

$$\text{Torqe(50Hp,1200rpm)}=\left\{\frac{50 \text{ x } 5250}{1175}\right\}=223 \text{ lbft}$$

This represents a torque increase of 50% for available starting torque for the same sized drive. To produce the same full rated torque of a 50HP, 1800RPM motor at 1800RPM, the 1200RPM motor must produce 148 lbft of torque or 148/223 = 66% of its full rated torque. Even though this motor is running into an overspeed situation, it can still successfully provide full rated torque of the 1800RPM application. The downside is that if high torque transients are required at the higher operating frequency, the 1200RPM motor will likely not produce as much peak torque as the 1800RPM motor would.

Please always bear in mind that at higher frequencies such as the 1200RPM motor running at 1800RPM, the motor drive package will likely provide less transient overload torque capability than the same sized inverter and same HP 1800RPM motor. Always confirm that the upper speed torque requirements of the load are covered.