

CEMA

Engineering Standard 351-2007

Variable Frequency Drive (VFD)
Selection
For Screw Feeders

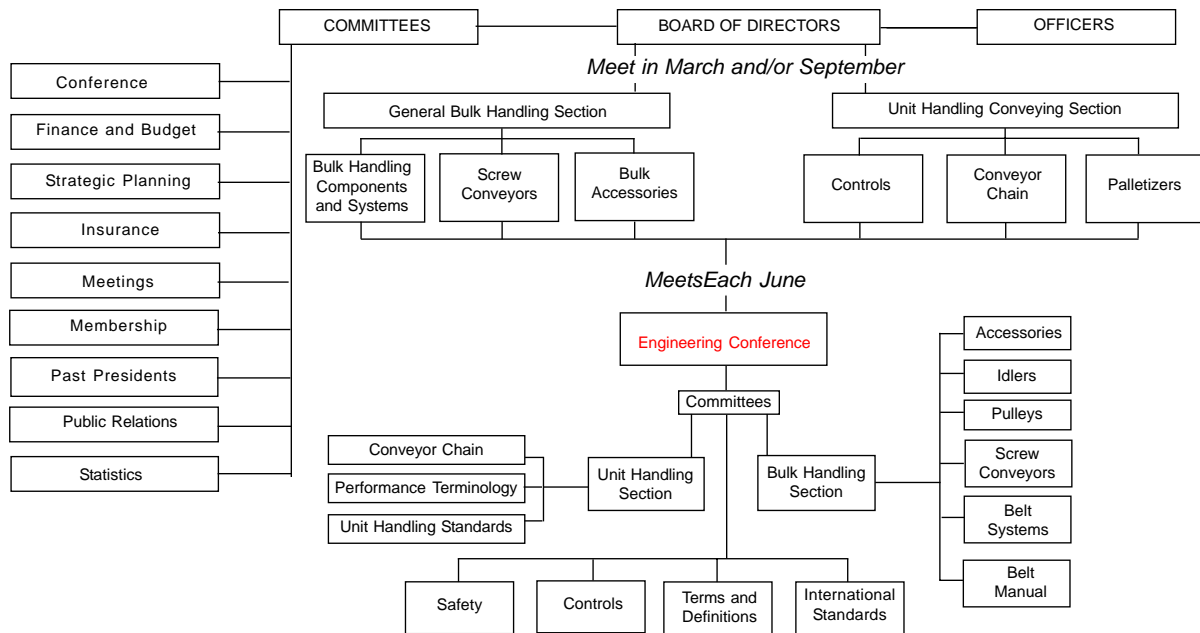
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Variable Frequency Drive (VFD) Selection For Screw Feeders

Screw feeders are designed to operate under flooded conditions with a head load of product on the screw or multiple screws. The unit must be designed to overcome the static condition of the screws and the force exerted by the product head load. The product head load exerts a downward force on the screws and creates frictional resistance. As a result, additional torque is required to start and operate a screw feeder when compared to a screw conveyor.

Special consideration is required when designing screw feeders. The starting torque requirements of screw feeders can be as much as 2-1/2 times the demand running torque. Torque is a function of horsepower and speed. Most screw feeders for industrial applications operate at speeds below 30-rpm. The lower screw feeder speed provides higher torque at the drive shaft.

Screw feeders are volumetric metering devices. A fixed volume of product is discharged with each revolution of the screw. The volumetric capacity of the screw feeder is based on the volume available in the last pitch before the shroud and the speed of the unit. All calculations are based on the capacity given in cubic feet per hour.

Procedure for Calculating Demand Horsepower for Screw Feeders

1. Perform screw feeder speed calculations for normal operating conditions to determine operating speed at the desired capacity, lowest density, degree of incline and screw pitch. Set the trough loading to 95-percent. Be sure to use the speed calculated for the appropriate housing style if the screw feeder is inclined.
2. Perform screw feeder horsepower calculations for worst-case operating conditions using the highest density and the volumetric capacity in cubic feet per hour as calculated in step 1. The screw feeder speed must be the same as calculated in step 1. The inlet length, head load height, product angle of repose and flight design must be taken into consideration to determine the demand horsepower requirements.
3. Perform screw feeder horsepower calculations with a range of material factors to determine high and low reference points for demand horsepower. The product will increase in density when stored in a hopper or silo due to compression. The material factor of the product will increase as the density increases. For example, if the average material factor for a product is 2.0, then perform horsepower calculations using material factors of 2.0, 3.0 and 4.0. Typically, the demand horsepower will not exceed the calculation using a material factor of 4.0.

Procedure for Determining Inverter Size for Screw Feeders (Standard is based on 230/460-volt, 3-phase motors)

1. **Determine the Motor Base Speed.** The motor base speed is determined by selecting a motor and gear reducer ratio that delivers the desired speed at the drive shaft of the screw feeder. Motors with 1800-rpm base speeds are most common in the U.S. 1200 and 3600-rpm motors are also available. Most commercially available industrial motors used in screw feeder applications are NEMA Design B motors. Depending on the horsepower and base speed, a NEMA design B motor can generate up to 275-percent of the nameplate rated torque at start up when started at full voltage across the line. Please refer to Figure 1 below. The same motor started on a VFD will

deliver torque at either the current overload of the VFD or the breakdown torque of the motor, whichever is lower.

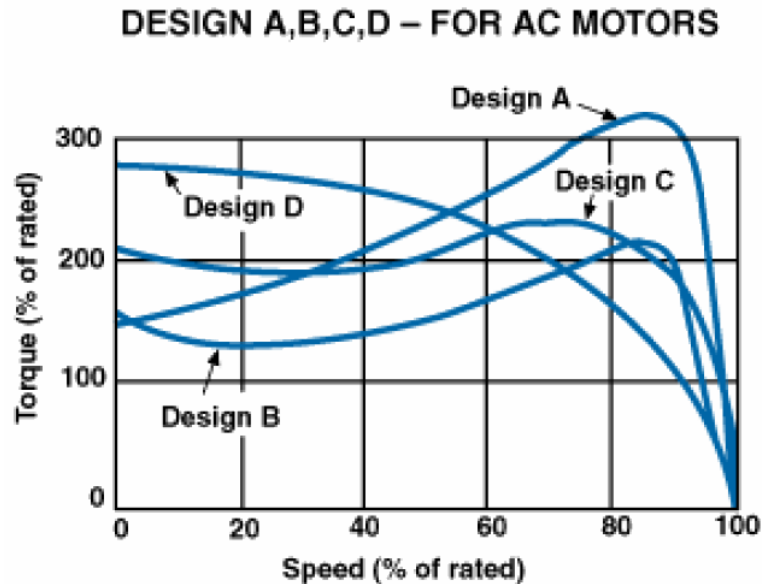


Figure 1.

(Courtesy of Baldor Dodge Reliance)

2. Determine the Turndown Ratio. The desired operating range of the screw feeder is based on the given customer's requirements. If the customer would like to meter anywhere from 100 to 1,000 cubic feet per hour of product, then in this example the turndown ratio of the motor is 10-to-1. The screw feeder speed and horsepower should be calculated for the maximum feedrate or worst-case operating conditions at motor nameplate frequency.

3. Determine Motor Type. It is important to select a motor that is capable of running with constant torque over the required speed range. Most standard TEFC motors are capable of either 4-to-1 or 10-to-1 turndown ratios on a constant torque load. Normally, to get higher turndown ratios, motor manufacturers have designed motors with cooling independent of motor speed with the use of auxiliary cooling fans. Motor manufacturers have also developed motors that are capable of developing constant torque from zero speed up to base motor speed.

4. Determine the VFD Size. The VFD must be sized for at least 2 times the full-load amps of the motor to allow for the high inrush of current during screw feeder starting. For example, a typical 20-hp premium efficient motor is rated for 49-amps at full-load and 230-volts. A minimum of 98-amps are required for sizing the VFD for start up conditions. Most VFDs limit the current output to 150-percent of full-load amps because torque and current are not proportional above 150-percent torque. A typical 20-hp VFD is rated for 1.5 times full-load amps or 74-amps and is not sufficient for the application. A typical 30-hp VFD is rated for 108-amps at 230-volts. The minimum VFD size would be 30-hp. A 40-hp VFD would be recommended.

5. Program the VFD. The VFD must be programmed for full torque boost with the least amount of time delay at start up. The time delay limits the inrush of current and creates a soft start. Soft starting a screw feeder under load is not recommended. The VFD soft-start feature must be disabled.

Other Factors to Consider

1. All motors are constant horsepower and variable torque above base speed. A motor can only generate nameplate horsepower up to base speed because the voltage is fixed by the power source. As motor speed increases above nameplate frequency it becomes constant horsepower and variable (decreasing) torque. Since the horsepower is fixed, the torque of the motor will decrease as the speed of the motor is increased. Please refer to Figure 2 below. Maximum motor speed is limited by rotor balance, bearing life, overheating and other physical limitations of the motor.

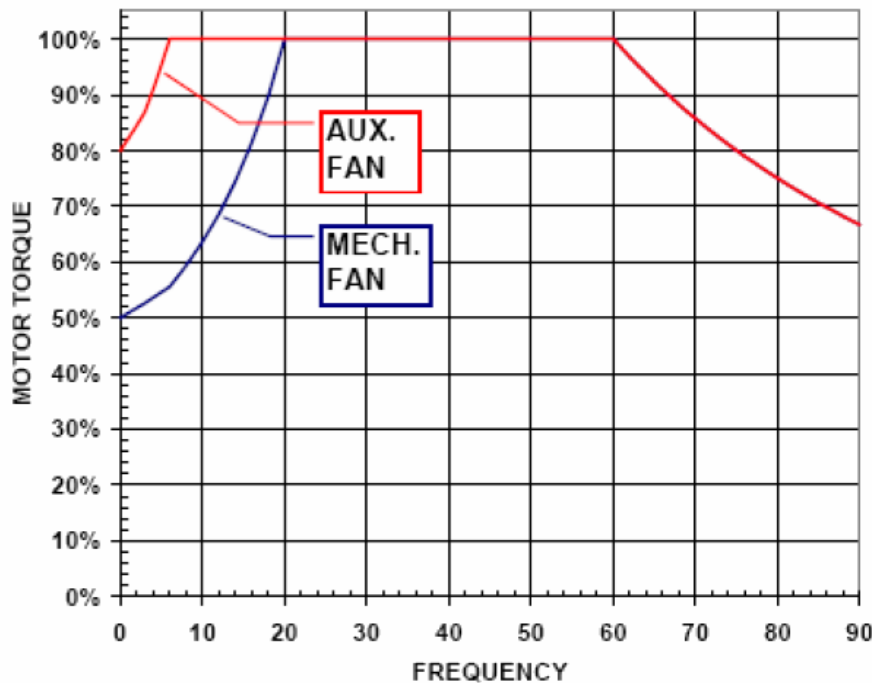


Figure 2.
(Courtesy of Nord Gear)

2. Alternate methods for determining screw feeder horsepower and VFD size are used by manufacturers. Some manufacturers choose to oversize the motor instead of the method described above. A successful method for determining screw feeder horsepower is to multiply the demand horsepower calculated at the minimum capacity by the turndown ratio and again by 2.5 to allow for start up conditions. This is a conservative method for determining screw feeder horsepower and the equipment must be sized for full-motor torque.

3. This Engineering Standard is a guide for manufacturers and users of screw feeders for the metering of bulk materials. The intent of the standard is to provide information to aid in the proper design and operation of screw feeders. Each manufacturer may have internal standards for designing screw feeders that are based on independent experience and research. Their internal standards may differ from the CEMA standard but provide similar results. Please consult a CEMA screw conveyor manufacturer for further information.

Note – Special thanks to Nord Gear and Reliance Electric for assistance in creating this standard.

