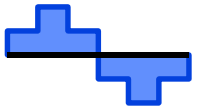
Selecting AF Drive Motors



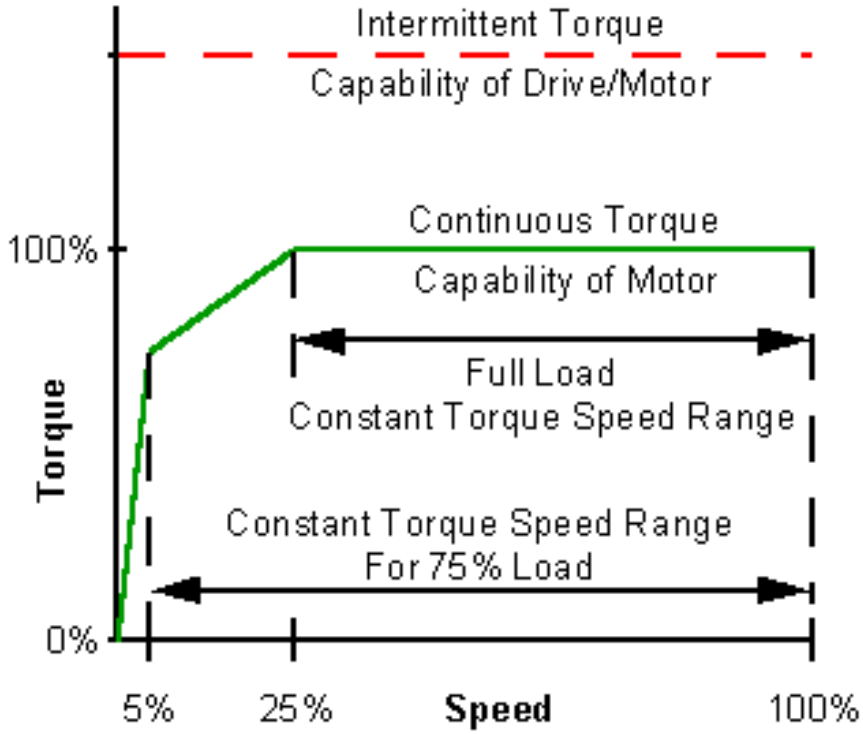
Introduction

- Although standard three-phase motors are used in most adjustable frequency drive applications, motors should not generally be selected, sized and applied in AF applications as if they were to be operated from 60 Hz sine wave power.
- The nature of the adjustable frequency power source and the complete range of operating conditions must be carefully considered to ensure that the application will be successful.

Selecting AF Drive Motors

Motor Requirements for Adjustable Frequency Applications

- Matching the torque-speed capability of the motor to the torque-speed requirements of the load.
  - Typical torque-speed capability curve for a motor:
  - Continuous torque capability
    - ≡ The maximum torque that can be supplied continuously without exceeding the motor's safe operating temperature
    - ≡ Capability is reduced at the low end of the speed range
    - ≡ At lower operating speeds, cooling air flow is reduced due to the reduced speed of the motor's self cooling fan and/or rotor fins



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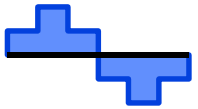


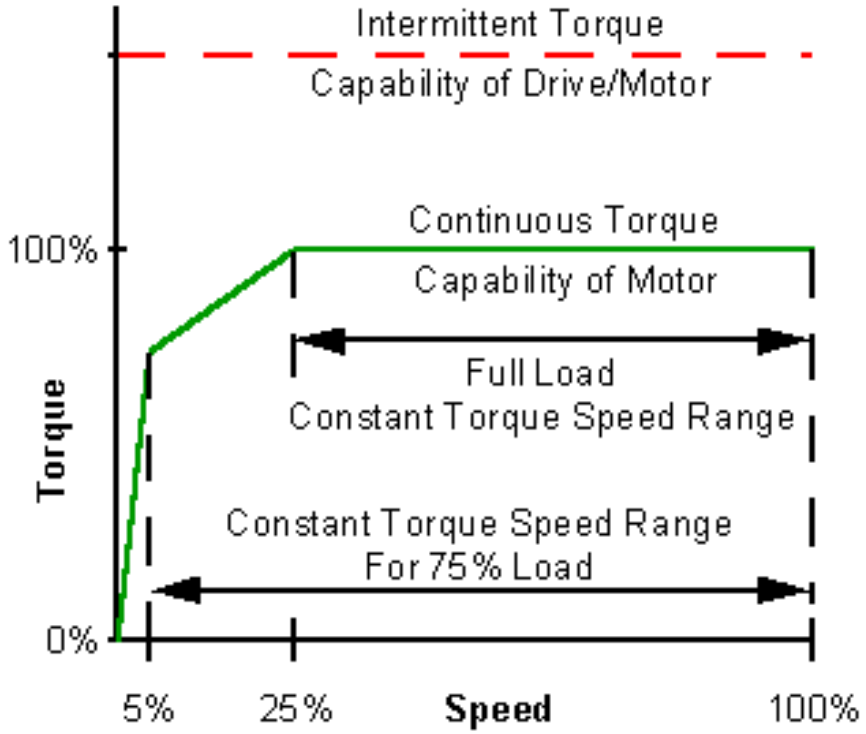
Motor Torque vs. Speed Capability

- Effect of AF Drive Output Waveform
  - A motor must dissipate additional heat when operating on an AF drive because it operates less efficiently on an AF waveform then on a purely sinusoidal waveform.
  - This means that the motor's continuous torque capability at full speed may be less when operating on an AF drive than when operating on sine wave power.
  - With older types of AF drives, the common practice was to specify a motor with 1.15 service factor, a motor designed to operate safely with a 15% overload.
  - With today,s PWM waveforms, the additional heating due to the waveform is generally considered to be negligible.

Selecting AF Drive Motors

Constant Torque Speed Range

- The maximum range of operating speeds for continuous operation at a constant load torque without exceeding the motor's safe operating temperature.
  - The figure shows the motor's full load constant torque speed range and the constant torque speed range for operation at 75% of rated torque.
  - Derating the drive to 75% of its normal rating would increase the speed range from 4:1 to 20:1.
  - Speed range is usually defined as the ratio of the maximum operating speed to the minimum operating speed. (100%/25% = 4:1)



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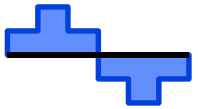
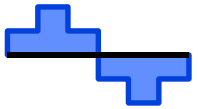


Intermittent Torque Capability

- A drive's intermittent torque capability is the torque that it can supply for a specified short period of time.
- An AF drive's intermittent torque capability is usually determined by the intermittent output current rating of the controller, but the motor may be the limiting factor in some cases.

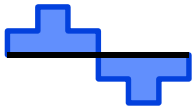
Selecting AF Drive Motors



Selecting the Motor − Fundamental Requirements

- The motor selected for an application must have a continuous torque capability curve that is above the torque vs. speed demand curve for the driven load throughout the continuos operating speed range.
- The intermittent torque capability of the motor must be sufficient to supply the torque required start and accelerate the load and to drive the load during momentary overload situations.

Selecting AF Drive Motors



Capabilities of Standard AC Motors

- For perhaps 25 years, it has been common practice to use standard off-the-shelf AC motors with adjustable frequency drives.
  - A few simple “rules of thumb” have been used to estimate the limits of safe operation for standard motors in adjustable frequency operation.
  - Historically, there have been very few problems with motors applied according to the generally accepted rules of thumb.
  - This may indicate that the rules of thumb were adequate or it may indicate that there were additional safety factors built into most applications.

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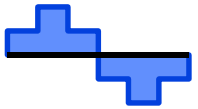
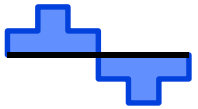


Capabilities of Standard AC Motors

- "Rules of Thumb" are not the best way to apply motors
  - Because of recent trends in motor design, the rules of thumb that were successfully used to select motors for many years may no longer be as successful as they were in the past.
- Better approaches are available today
  - Use motors specifically designed for AF duty.
  - Use capability curves published by motor manufacturers to define the limits of adjustable speed operation for standard motors.

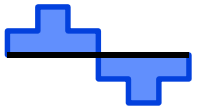
Selecting AF Drive Motors



Inverter Duty Motors

- Designers of motors and AF drives have long known that that it was possible to design motors with features and capabilities that would make them significantly superior to standard motors in adjustable speed applications.
  - Most manufacturers now offer such motors, calling them "Inverter Duty Motors," "Adjustable Speed Motors" or "AFD Motors."
  - NEMA Standard MG 1, part 31 specifies performance standards for "Definite-Purpose Inverter-Fed Motors."
  - An AFD motor should be considered whenever a new motor will be purchased for an AF application.
  - An AFD motor should also be considered whenever the motor on an existing AF application needs to be rewound or replaced.

Selecting AF Drive Motors



Inverter Duty Motors

- AFD motors are generally specified as suitable for variable torque duty or suitable for constant torque duty over a specified speed range.
- Capability curves should be available from the motor manufacturer.

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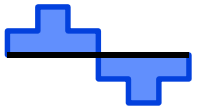
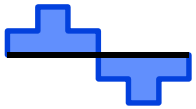


Inverter Duty Motors

- Special cooling systems
  - In applications that require extended periods of low speed applications, totally enclosed blower cooled (TEBC), totally enclosed air over (TEAO) or separately ventilated motors may be used.
  - TEBC and TEAO motors are similar to ODP and TEFC motors except that a separately powered fan or blower is used to move air through or over the surface of the motor.
  - Separately ventilated motors are cooled by air that is ducted in from an external source.
  - The key characteristic of TEBC, TEAO and separately ventilated motors is that the flow of cooling air does not depend of the motor's operating speed..

Selecting AF Drive Motors



Inverter Duty Motors

- In addition to the thermal concerns, AFD motor designs address several other effects of AF waveforms.
  - The motor insulation system is designed to withstand the higher peak voltages and fast rates of voltage change that may be found in AF applications.
  - Consideration is given to the possibility of bearing damage due to high frequency ground leakage currents that can flow through the shaft and bearings.
  - Designs may also include features that minimize the effect of the AF waveform on mechanical vibration and acoustical noise.

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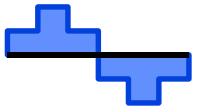
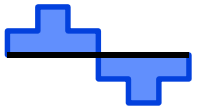


Inverter Duty Motors

- Motor Accessories
  - Motor accessories are additional items of equipment that are mounted on the motor housing.
  - The one accessory item that has already been discussed is the separately powered blower or fan that is used to cool a TEBC or TEAO motor.
  - Another accessory that is unique to AFD motors is the tachometer generator or encoder.
    - ≡ Tachometer generators and encoders provide signals that are used by the AF control system to determine shaft speed, direction and angular position.
    - ≡ Shaft speed, direction and position information is used to perform a number of control functions in high performance applications.

Selecting AF Drive Motors



Special Application Considerations

- Adjustable frequency drives are usually designed for use with 4-pole motors.
  - Most drives can easily be used with 2-pole and 6-pole motors as well.
  - Motors with 8 or more poles may be more difficult to apply.
    - ≡ At a minimum, the drive will probably need to be oversized to supply the increased current usually required by motors of 8 or more poles.

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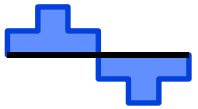

Special Application Considerations

- Motors other than NEMA design B motors are not usually recommended for use with AF drives.
- With AF drives, motors can be operated at frequencies above 60 Hz. When a motor is operated above 60 Hz, the operating speed exceeds the rated speed marked on the nameplate.
- The use of any type of motor other than NEMA design B and operation above 60 Hz is considered to be advanced application topics.