

MEDIUM VOLTAGE MOTOR STARTING

As a general rule, large induction motors have limitations on frequency of starting.

During acceleration to full speed, the motor generates heating of the rotor and stator at a rate substantially higher than during full load running conditions. If the motor is started too frequently, this rate of heating can cause damage to either the stator insulation or the rotor bars and end rings. The specific motor design determines whether such starting condition is rotor limited or stator limited, but the large majority of motors running 1800rpm or slower are rotor limited.

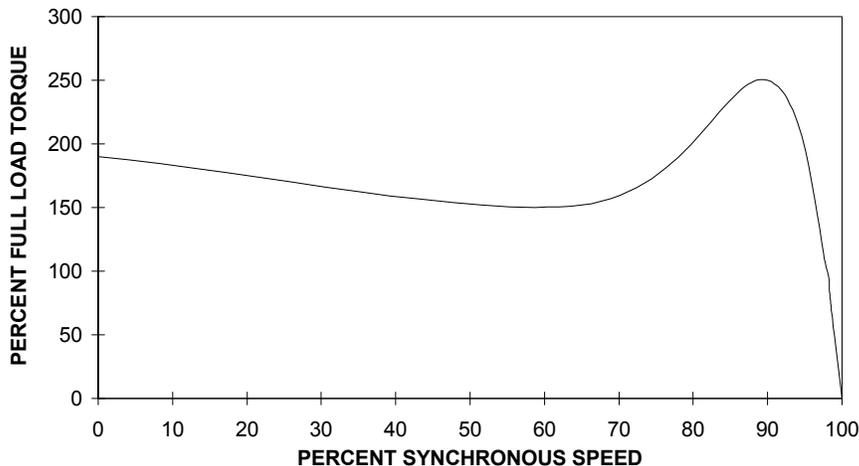
The motor is accelerated to full speed by the acceleration torque. Acceleration torque is defined as the difference between the motor speed vs torque curve and the load speed vs torque curve. The acceleration time is defined as follows:

$$t = \frac{wk^2 \times \text{rpm}}{308 \times T_a}$$

where:

t = acceleration time
rpm = change in speed (rpm)
T_a = acceleration torque

Typical Speed-Torque Curve



Nema MG1 standards include the following:

1. A table showing standard maximum values for load inertia (WK^2)
2. A statement that, if load inertia is less than or equal to NEMA values, and the load torque characteristic varies as the square of the speed, the motor should be capable of initially starting once providing it has been running long enough to stabilize temperature-wise. It can start twice (coasting to rest between starts) if the motor has been turned off long enough to cool to within $5^{\circ}C$ of ambient.

It should be noted that large motors are generally not rated for starts per hour, and the above NEMA 2 cold / 1 hot capability does not mean "2 cold / 1 hot starts per hour". The NEMA definition of 2 consecutive "**Cold**" starts is the load is started with the motor at ambient temperature. Once the motor reaches full speed, it can be turned off and after coasting to a stop, it can be restarted. The motor must be allowed to cool to the normal full load operating temperature before being allowed to restart. 1 **hot start** means that a motor can be restarted once after reaching normal operating temperature and must cool back down to normal operating temperature before being restarted. Starting frequency after initial starting for a typical motor with less than NEMA load inertia, is 15 to 40 minutes wait if running, 35 to 90 minutes wait if turned off. High inertia loads may require longer waiting times.

Special starting requirements

Special motor design may be required for the following conditions:

- Load inertia exceeds NEMA standard values
- Load torques exceed the "square curve" defined above
- Reduced voltage starting will occur
- Specific starting frequency is required

If any one or more of these conditions occur, it may take a special motor design to properly start the motor.

If the motor voltage is reduced, the motor torque is reduced as the square of the voltage level. Thus, the selection of a low voltage tap on an autotransformer or reactor starter, or the use of an electronic soft start system, can cause motor torques to drop below load torques at some speed during acceleration. If this happens, the motor does not accelerate to full speed. An analysis should always be done to be sure reduced voltage does not become a problem.

It should also be noted that electronic soft start systems which gradually change the voltage applied to a motor do not allow the motor to be started more frequently.

Starting by the use of a variable frequency drive, on the other hand, causes much less heating effect during start. If for example, the current limit is set to 100%, there would be no theoretical limit to the number of successive starts. If the current limit is set to 150%, the heating effect will be in the order of 225% of the normal full load operation. NEMA MG-1 Section 31 offers some guidelines as to the number and duration of repetitive overloads that a motor should be designed to withstand. The manufacturer of the motor should be consulted when excessive overloads will be subjected to the motor.