NEMA Standards for Electric Motors

NEMA (National Electrical Manufacturers Association) developed a set of standards relating to electric motors that include design classes, frame sizes, enclosures, and configurations. A basic knowledge of NEMA standards can prove invaluable when looking for a new, replacement, or surplus motor.

NEMA Design Classes

NEMA classes categorize electric motors based on a motor's starting-torque and its accelerating load. The four standard NEMA design classes are as follows:

NEMA Class A motors have a maximum 5% slip with a high to medium starting current, normal locked rotor torque, and normal breakdown torque. These characteristics make them well suited for a wide vareity of applications and they are often found powering fans and pumps.

NEMA Class B motors also have a maximum 5% slip and a normal breakdown torque but include a low starting current, and a high locked rotor torque. These motors are well suited for various applications that require normal starting torques and are commonly found in HVAC systems where they are used with pumps, blowers, and fans.

NEMA Class C motors have a maximum 5% slip, low starting current, high locked rotor torque and a normal breakdown torque. They work well with conveyors and positive displacement pumps that require a high starting torque and high inertia at startup.

NEMA Class D motors exhibit a maximum 5 to 13% slip with a low starting current and a very high locked rotor torque. Applications that require very high inertia starts, like hoists and cranes, often use Class D motors.

There are also large electric motors (e.g., 400HP or more, Siemens manufactures them up to 18,000 hp in the USA) and medium to high voltage

motors that are referred to as Above-NEMA, ANEMA, A NEMA, or A-NEMA electric motors. These motors do not adhere to a standard NEMA classifications or NEMA frame size (which we will talk about in a moment).

NEMA Frames

There is a great deal of information contained in NEMA Frame codes, including key motor dimensions. In any standard frame number designation, you'll see either two or three numbers as well as a possible prefix before the numbers or a suffix after the numbers. The numbers are part of the NEMA frame size.

NEMA Frame Size

NEMA frame size numbers provide you with key information about the different dimensions of an electric motor. While they don't tell you the horsepower, the larger numbers are normally associated with more horsepower.

The letter T in a frame size (which we will talk about in a moment) tells you that the frame number has been standardized so that specifications such as horsepower, speed, and certain key dimensions will be the same for all motors with that frame size. The key dimensions will normally include things such as the shaft diameter, height, and length as well as mounting-base dimensions and bolt-hole sizes. You can also use the frame size to refer to tables of NEMA frame assignments to find out other specifications such as speed and power.

NEMA Frame Number Prefixes

When you see a letter before the NEMA frame number, be aware that it's a manufacturer specific designation. That means it does not have a standardized meaning, and the meaning it has varies from manufacturer to manufacturer.

NEMA Frame Number Suffixes

You'll notice a letter suffix after the NEMA frame number and it, too, has been standardized by NEMA regulations. These suffixes provide key information about the motor, how it is mounted, what its purpose is, what type of shafts it has, and more. Here is a summary of what the suffixes mean:

- C: type C face mounting on DE

- D: type D flange mounting on DE
- H: designated 56H motors have two sets of 2F mounting holes, 3 in. and 5 in.
- J: NEMA C face mount, threaded shaft pump motor
- JM: face-mounted, close-coupled pump motors with specific dimensions and bearings
- JP: type C face-mounted, close-coupled pump motors with specific dimensions and bearings
- K: has a hub for sump pump mounting
- LP or LPH: type P flange-mounted, vertical solid-shaft motors
- M or N: flange mount for oil burner motors (6 3/4” flange for M, 7 1/4” flange for N)
- P or PH: type P flange-mounted vertical hollow-shaft motors
- R: drive end tapered shaft connection
- S: Standard short shaft for direct connection
- T: standard dimensions for this frame designation have been established
- V: vertical mounting only
- VP: type P-flange mounted, vertical solid shaft motor
- X: wound-rotor crange motor with a double shaft extension
- Y: special mounting dimensions, contact manufacturer for details
- Z: all mounting dimensions are standard except the shaft dimensions OR used to designate double shaft extensions, but in either case contact the manufacturer for details

NEMA Standard Enclosures

NEMA designates certain enclosure types for motors and divides them into two categories: open machines and totally enclosed machines. What follows

are descriptions of the NEMA standard enclosures that you are most likely to encounter.

NEMA Open Machines

Open Drip Proof (ODP) motors allow airflow and have internal fans to assist in maintaining air movement to help keep the motor cool. The enclosure around these motors has ventilator openings that prevent liquids and solids from making their way in from angles between 0° to 15°. They are mainly used in indoor environments where the atmosphere is clean.

Weather Protected I (WPI) enclosures add screens to an ODPmotor so large particles cannot enter the motor. These are intended for protected areas that have environments that are relatively clean.

Weather Protected II (WPII) enclosures, on the other hand, are made for more rugged indoor and outdoor environments that include dust, water spray, and even 100 MPH winds driving rain at the motor. To protect the motor, there are baffles on the inlet of the motor that force the air to change its direction 3 times by 90°each time.

NEMA Totally Enclosed Machines

Totally Enclosed Fan Cooled (TEFC) motors are made for working conditions where contaminants can pose major problems. They are, as the name implies, totally enclosed and depend on an external fan to circulate cooling air. **Totally Enclosed Non-Vented (TENV)** motors have no air openings but are neither liquid-tight nor air-tight.

Washdown Enclosures (WDN) motors are designed to facilitate easy cleaning and intended for environments where there is a need for regular sanitizing or cleaning, such as food or beverage processing.

Explosion-Proof (XPRF) motors have enclosures engineered to withstand an internal explosion resulting from vapor or gas without rupturing. These are intended for use in extremely hazardous environments.

Basic NEMA Motor Configurations

There are three commonly used NEMA motor configurations: standard duty/general purpose, severe duty, and IEEE 841 Motors. They intended for

different applications and, as a result, usually have different types of enclosures, bearings, and appropriate work environments.

Standard Duty or General Purpose Motors

Standard duty or general purpose motors are most often ODP or TEFC motors and are manufactured to meet NEMA premium efficiency regulations. These motors will most likely have either ball bearings or roller bearings if they are intended for an application with a belted high radial load. They are not appropriate for use in harsh, dirty environments.

Severe Duty Motors

Severe duty motors only have TEFC enclosures. They are made for tougher applications and harsh environments such as chemical processing, mining, foundry, pulp and paper, waste management and petro/chemical applications.

IEEE 841 Motors

IEEE 841 motors are not NEMA motors, but rather are manufactured to the IEEE 841-2009 standard for environments that require more than just a severe duty motor. This particular IEEE specification covers three-phase motors from 1 to 500 HP, 1800RPM, 3600RPM, 1200RPM, and 900RPM.

NEMA Motor Insulation Classes

There are also NEMA motor insulation classes that describe the ability of a motor's winding to withstand heat. The four most common classes are listed below and they specify the allowable rise above a 40°C ambient temperature.

Class A:

- Maximum Temperature Rise: 60°C,
- Hot-spot Over Temperature Allowance: 5°C
- Maximum Winding Temperature: 105°C

Class B:

- Maximum Temperature Rise: 80°C

- Hot-spot Over Temperature Allowance: 10°C
- Maximum Winding Temperature: 130°C

Class F:

- Maximum Temperature Rise: 105°C
- Hot-spot Over Temperature Allowance: 10°C
- Maximum Winding Temperature: 155°C

Class H:

- Maximum Temperature Rise: 125°C
- Hot-spot Over Temperature Allowance: 15°C
- Maximum Winding Temperature: 180°C

Conclusion

NEMA standards are an important way to specify the type of motor that you need and to evaluate the suitability of a motor for your application. These standards cover key factors ranging from size and suitability to enclosures and even winding insulation. If you have any questions about NEMA standards for electric motors, the experts here at HECO would be glad to assist you.