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Understanding Motor Nameplate Information - NEMA v/s IEC Standards

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Understanding Motor Nameplate Information
NEMA v/s IEC Standards

Course Content

The motor standards can be grouped into two major categories: NEMA and IEC (and its derivatives).

In North America, the National Electric Manufacturers Association (NEMA) sets motor standards, including what should go on the nameplate (NEMA Standard MG 1-10.40 "Nameplate Marking for Medium Single-Phase and Polyphase Induction Motors").

In most of the rest of the world, the International Electrotechnical Commission (IEC) sets the standards. Or at least many countries base their standards very closely on the IEC standards (for example, Germany's VDE 0530 standard and Great Britain's BS 2613 Standard are close to IEC with minor exceptions.

The National Electrical Manufacturer's Association (NEMA) specifies that every motor nameplate must show these specific items:

1) Manufacturer's type
2) Rated volts and full load amps
3) Rated frequency & number of phases
4) Rated full load speed
5) Rated temperature rise or the insulation system class
6) Time rating
7) Rated horsepower
8) Locked rotor indicating code letter
9) Service Factor
10) Efficiency
11) Frame Size
12) Design Code

Additional information may also normally appear on the nameplates. This course shall examine closely the required nameplate items starting with the NEMA standards followed by comparing where IEC information differs from NEMA.

#1:
MANUFACTURER'S TYPE

NEMA requires a manufacturer's type, but there is no industry standard for what this is. It is sometimes used to define 1 or 3-phase; single or multi-speed; construction, etc. The "type" definition varies from manufacturer to manufacturer.

Below are some of the "types" of motors that may be encountered:

1) ***1-Phase, Shaded Pole:*** Lowest starting torque, low cost, low efficiency, no capacitors. No start switch. Used on small direct-drive fans and small gear motors.

2) ***1-Phase, PSC (Permanent Split Capacitor):*** Similar to shaded pole applications except much higher efficiency, lower current and higher horsepower capability. Has run capacitor in circuit at all times.

3) ***1-Phase, Split Phase:*** Moderate to low starting torque, no capacitor and has starting switch. Used on easy start, belt-drive fans and blowers light start pump applications and gear motors.

4) ***1-Phase, Capacitor-Start:*** Designed in both moderate and high starting torque types with both having moderate starting current and high breakdown torque. Uses include conveyors and air compressors.

5) ***3-Phase:*** Generally 3-phase induction motors have a high starting torque, high power factor, high efficiency, and low current. Does not use a switch, capacitor or relay for starting. Suitable for use on larger commercial and industrial applications.

6) ***AC/DC (Universal or Series wound):*** Operates on AC (60 or 50 Hz) power. High speed. Speed drops rapidly as load increases. Used for drills, saws, etc., where high output and small size are desired and speed characteristic and limited life (primarily of brushes) is acceptable.

7) ***Shunt Wound and Permanent Magnet DC:*** High starting and breakdown torque. Provide smooth operation at low speeds. Used on constant or diminishing torque applications with Type K rectified DC power.

Motors can also be classified by their purpose:

1) ***General Purpose Motors*** are designed for mechanical loads and hard to start loads, including conveyors, belt-driven equipment, machine tools, reciprocating pumps and compressors, etc. Their bearings can handle heavier radial and axial loads, and their physical construction is more heavy-duty than some other motors

2) ***Special Purpose Motors*** are specifically designed for certain applications. For example, HVAC motors are primarily designed for fans, centrifugal pumps, small tools, office equipment, and other light to medium duty applications. Other types of definite duty motors include wash down, hazardous location, farm duty, pump duty, universal AC/DC, vacuum, etc.

Some manufactures simply add the model, date, & serial number here to aid in identification.

#2:

RATED VOLTS

The rated voltage is the voltage at which the motor is designed to operate and yield optimal performance. Nameplate-defined parameters for the motor such as power factor, efficiency, torque, and current are at rated voltage and frequency. Application at other than nameplate voltage will likely produce different performance.

Line voltage will fluctuate due to a variety of factors. In recognition of the fact that there will be a voltage drop from the network to the motor terminals, motors are designed with a 10% tolerance for voltage above and below the rated nameplate value. Thus, a motor with a rated nameplate voltage of 460V should be expected to operate successfully between 414V and 506V. At these extremes, motor will not run at its peak performance; however it will withstand these conditions.

Manufacturers often put a wide variety of voltages on the nameplate. For example, a motor wound for 230 and 460 V (230/460 V) but operable on 208 V. In this case the nameplate would read 208-230/460 and will have degraded performance at 208 V.

#3:

FULL LOAD AMPS (FLA)

When the full-load torque and horsepower is reached, the corresponding amperage is known as the full-load amperage (FLA). This value is determined by laboratory tests; the value is usually rounded up slightly and recorded as the nameplate value. Rounding up allows for manufacturing variations that can occur and some normal voltage variations that might increase the full-load amps of the motor. The nameplate FLA is used to select the correct wire size, motor starter, and overload protection devices necessary to serve and protect the motor.

Rated full load current is often abbreviated as ‘FLA” on the nameplate. Unbalanced phases, under-voltage conditions, or both, cause current to deviate from nameplate amps.

#4:

RATED FREQUENCY

Rated frequency is the frequency the motor is designed to operate and is represented by Hertz (Hz, cycles per second). In North America & Canada, this frequency is 60 Hz (cycles). In other parts of the world, the frequency may be 50 or 60 Hz. The motors designed to operate varying speeds using variable frequency drive (VFD); the frequency range is normally given.

#5:

NUMBER OF PHASES

This represents the number of AC power lines supplying the motor. You either have a single-phase or 3-phase motor.

#6:
FULL LOAD RPM

Full load RPM (Revolutions per Minute) of the motor is approximate speed under full-load conditions, when voltage and frequency are at the rated values. It is generally given as "RPM" on the nameplate.

An induction motor's speed is always less than synchronous speed and it drops off as load increases. For example, for 1800 rpm synchronous speed, an induction motor might have a full-load speed of 1748 rpm. On standard induction motors, the full-load speed is typically 96% to 99% of the no-load speed. This is known as slip.

Multi-speed shaded pole and PSC motors show maximum speed first, followed by total number of speeds (i.e., 3000/3-Spd). Multi-speed split phase and capacitor-start motors have maximum speed shown first, followed by second speed (i.e., 1725/1140). RPM rating for a gear motor represents output shaft speed.

Note: "High" efficiency motors have usually higher speed ratings than comparable sized standard efficiency motors. This higher operating speed can actually increase power consumption in centrifugal loads (e.g., pumps and fans). For centrifugal loads, power varies as the cube of speed. Thus, a 1% increase in speed will result in a 3% increase in power (1.01^3= 1.03).

#7:
SYNCHRONOUS SPEED

Synchronous speed is the theoretical speed of a motor based on the rotating magnetic field. This is determined by the following:

S = (120 x F)/P
S = speed in RPM
F = frequency in hertz
P = Number of poles in motor

Or, if you know the number of poles in your motor, you can determine the speed by the following table:

# of Poles	Synchronous Speed	Actual Speed
2	3600	3450
4	1800	1725

6	1200	1140
8	900	850

#8:

INSULATION CLASS

Often abbreviated "INSUL CLASS" on nameplates, it is an industry standard classification of the thermal tolerance of the motor winding. Insulation is crucial in a motor. This is determined by the ambient temperature, the heat generated at fully loaded conditions (temperature rise), and the thermal capacity of the motor insulation. These materials are classified as A, B, F, and H. The letter designation indicates the thermal tolerance, or winding's ability to survive a specified operating temperature for a specified period of time.

The classes are based on adding the ambient temperature and the operational heat created by the motor. They are shown below.

Class	20,000 Hour Life Temperature
A	105°C
B	130°C
F	155°C
H	180°C

Insulation classes of a letter deeper into the alphabet perform better. For example, class F insulation has a longer nominal life at a given operating temperature than class A, or for a given life it can survive higher temperatures.

#9:

MAXIMUM AMBIENT TEMPERATURE

The nameplate lists the maximum ambient temperature at which the motor can operate and still be within the tolerance of the insulation class at the maximum temperature rise. It is often abbreviated as "AMB" on the nameplate.

 # 10:

ALTITUDE

This indicates the maximum height above sea level at which the motor will remain within its design temperature rise, meeting all other nameplate data. If the motor operates below this altitude, it will run cooler. *At higher altitudes, the motor would tend to run hotter because the thinner air cannot remove the heat so effectively, and the motor may have to be derated.* Not every nameplate has an altitude rating.

11:
TIME RATING

Time rating or duty specifies the length of time the motor can operate at its rated load safely and indicates whether the motor is rated for continuous duty. This is shown as "CONT" on the nameplate.

Standard motors are rated for continuous duty (24/7) at their rated load and maximum ambient temperature. Specialized motors can be designed for “short-time” requirements where intermittent duty is all that's needed.

These motors can carry a short-time rating from 5 minutes to 60 minutes. The NEMA definition for short-time motors is as follows: “All short-time ratings are based upon corresponding short-time load tests, which shall commence only when the windings and other parts of the motor are within 5°C of the ambient temperature at the time of the test.” By using short-time ratings, it's possible to reduce the size, weight, and cost of the motor required for certain applications. For example, you may choose to install an induction motor with a 15-minute rating to power a pre-operation oil pump used to pre-lube a gas turbine unit because it would be unusual for this type of motor to be operated for more than 15 minutes at a time.

Other examples of intermittent duty applications include crane, hose, valve actuator etc. *The intermittent duty rating is typically expressed in minutes.*

12:
HORSEPOWER

Shaft horsepower is a measure of the motor's mechanical output rating, its ability to deliver the torque required for the load at rated speed. It is usually given as "HP" on the nameplate and is calculated as follows:

Horsepower (hp) = [Motor Speed ×Torque (lb-ft)] ÷5,250

The standardized NEMA table of motor horsepower ratings runs from 1 hp to 450 hp. When application horsepower requirements fall between two standardized values, the larger size is usually chosen.

13:
TORQUE

Torque is the turning or twisting force supplied by a drive to the load, measured in inch pounds or foot-pounds. Torque and horsepower are related as shown:

HP= (Torque X Speed)/Constant

If Torque is given in ft-lbs, the constant is 5252

If Torque is given in in-lbs the constant is 63,025

14:
LOCKED ROTOR kVA CODE

When AC motors are started with full voltage applied, they create an inrush current that's usually many times greater than the value of the full-load current. The value of this high current can be important on some installations because it can cause a voltage dip that might affect other equipment. The start inrush current has been standardized and defined by a series of code letters which group motors based on the amount of inrush in terms of kilovolt amperes. The code letter defines low and high voltage inrush values on dual voltage motors. These values can be used for sizing starters, etc.

Code	KVA/HP	Approx. Mid-Range Value
A	0.00-3.14	1.6
B	3.15-3.54	3.3
C	3.55-3.99	3.8
D	4.00-4.49	4.3
E	4.50-4.99	4.7
F	5.00-5.59	5.3
G	5.60-6.29	5.9
H	6.30-7.09	6.7
J	7.10-7.99	7.5
K	8.00-8.99	8.5
L	9.00-9.99	9.5
M	10.00-11.99	10.6
N	11.20-12.49	11.8

P	12.50-13.99	13.2
R	14.00-15.99	15.0

The chart provides the locked-rotor code letter that defines an inrush current a motor requires when starting it. The chart defines the locked-rotor kVA on a per-HP basis and indicates that inrush current per HP increases per letter. Replacing a motor with a higher locked rotor code may require additional upstream electrical equipment to handle the higher inrush currents.

Using this chart and the job voltage, you can calculate 'the across the line starting inrush' by using the following:

200 Volts LRA = Code letter value x HP x 2.9

230 Volts LRA = Code letter valve x HP x 2.5

460 Volts LRA = Code letter value x HP x 1.25

This is used by the installer to determine the proper branch circuit protection rating.

15:
POWER FACTOR (PF)

Power factor on the nameplate is sometimes abbreviated as PF or P.F. Power factor is the ratio of active power (W) to apparent power (VA), expressed as %age. The power factor is also equal to the cosine ("cos") of the angle formed by the lag between the current with respect to the voltage.

For induction motors, the power factor varies with load. Power factor is minimum at no load and increases as additional load is applied to the motor. Power factor usually reaches a peak at or near full load on the motor.

It and can vary from 0 to 1 and is for the full load condition. It is desirable to have high power factors close to unity (100%). The power factor can be improved by adding capacitors.

In NEMA motors the power factor is abbreviated as "PF" and for IEC motors the power factor is tagged as "cos".

16:
SERVICE FACTOR (SF)

Motor Service Factor (SF) is the percentage of overloading the motor can handle for short periods when operating normally within the correct voltage tolerances.

SF is a factor that when multiplied by horsepower, gives the allowable horsepower loading, which may be carried under the conditions specified for the service factor at rated voltage and frequency. This is practical as it gives you some 'fudge' in estimating horsepower needs and actual running horsepower requirements. It also allows for cooler winding temperatures at rated load, protects against intermittent heat rises, and helps to offset low or unbalanced line voltages. For example, the standard SF for open drip-proof (ODP) motors is 1.15. This means that a 10-hp motor with a 1.15 SF could provide 11.5 hp when required for short-term use. Some fractional horsepower motors have higher service factors, such as 1.25, 1.35, and even 1.50.

In general, it's not a good practice to size motors to operate continuously above rated load in the service factor area. Operating a motor at overloads allowed by the service factor for extended periods can result in reduced speed, overheating, decreased efficiency, decreased power factor, etc. Motors may not provide adequate starting and pull-out torques, and incorrect starter/overload sizing is possible. This in turn affects the overall life span of the motor.

Most motors have a duty factor of 1.15 for open motors and 1.0 for totally closed motors. Traditionally, totally enclosed fan cooled (TEFC) motors had an SF of 1.0, but most manufacturers now offer TEFC motors with service factors of 1.15, the same as on ODP motors. Most hazardous location motors are made with an SF of 1.0, but some specialized units are available for Class I applications with a service factor of 1.15.

The service factor is required to appear on the nameplate only if it is higher than 1.0.

17:
FULL LOAD NOMINAL EFFICIENCY

Efficiency is the ratio of the power output divided by the power input. The efficiency is given as a percentage and indicates how well the motor converts electrical power into mechanical power. The closer this value is to 100%, the lower the electricity consumption cost is going to be.

New motors usually have a "nominal" efficiency stamped on the nameplate. This is the average efficiency of this motor. However, the actual efficiency can fall within a specified band of the nominal efficiency, so the actual may be lower or higher.

Generally, larger motors will be more efficient than smaller motors. Today's premium efficiency 3-phase motors have efficiencies ranging from 86.5% at 1 hp to 95.8% at 300 hp. The efficiency value that appears on the nameplate is the “nominal full-load efficiency” as determined using a very accurate dynamometer and a procedure described by IEEE Standard 112, Method B. The nominal value is what the average would be if a substantial number of identical motors were tested and the averages of the batch were determined. Some motors might have a higher value and others might be lower, but the average of all units tested is shown as the nominal nameplate value. Thus essentially the rating Nom Eff. 92.1 means this is an average efficiency of this motor model, but actual efficiency may vary.

The efficiency is reduced by any form of heat, including friction, stator winding loss, rotor loss, core loss (hysteresis and eddy current), etc. The actual motor efficiency is guaranteed to be within a band of this nominal efficiency by the manufacturer. The efficiency band varies from manufacturer to manufacturer. The maximum allowable "band" is 20% set by NEMA. This is a large range; therefore pay close attention to the manufacturer's actual minimum guarantee!

18:
FRAME SIZE (optional)

Under the NEMA system, most motor dimensions are standardized and categorized by a frame size number and letter designation. The number describes the mounting dimensions, including foot hole mounting pattern, shaft diameter, shaft height, etc. It does not define overall length and height, conduit box extension length, etc.

NEMA (National Electrical Manufacturers Association) frame size refers to mounting only and has no direct bearing on the motor body diameter. As a frame number becomes higher so in general does the physical size of the motor and the horsepower. There are many motors of the same horsepower built in different frames.

By NEMA definition, two-digit frame numbers are fractional frames even though 1 HP or larger motors may be built in them. The two digits represent the shaft height of the motor from the bottom of the base in sixteenths of an inch. For example, a 56-frame motor would have a shaft height (“D” dimension) of 56/16 of an inch, or 3.5 inches.

On larger 3-digit frame size motors, 143T through 449T, a slightly different system is used. The first 2 digits of the frame size divided by 4 equals the height (in inches) of the shaft centerline from the bottom of the mounting feet. For example, a 326T frame would have a “D” dimension of 32 ÷ 4 or 8 inches. Although no direct inch measurement relates to it, the third digit of three-digit frame sizes, in this case a 6, is an indication of the motor body's length or indicates the distance between the holes parallel to the base. The longer the motor body, the longer the distance between mounting bolt holes in the base (i.e. greater “F” dimension). For example, a 145T frame has a larger “F” dimension than does a 143T frame. Three-digit frame numbers are by definition integral frames. It has no significance in a footless motor.

When working with metric motors (IEC type), the concept is the same as noted above with one exception — the shaft height above the base is now noted in millimeters rather than inches. The frame size is the shaft height in millimeters. (The details are further described later in the course)

Some common frames examples include:

Number	Definition
C	NEMA C face mounting (specify with or without rigid base)
D	NEMA D flange mounting (specify with or without rigid base)

Number	Definition
H	Indicates a frame with rigid base having an F dimension larger than that of the same frame without the suffix H. For example, combinations of 56H base motors have mounting holes for NEMA 56 and NEMA 143-5T and a standard NEMA 56 shaft.
J	NEMA C face, threaded shaft pump motor
JM	Close-coupled pump motor with specific dimensions and bearings
JP	Closed-coupled pump motor with specific dimensions and bearings
M	6 3/4" flange (oil burner)
N	7 1/4" flange (oil burner)
T, TS	Integral horsepower NEMA standard shaft dimensions if no additional letters follow the "T" or "TS."
TS	Motor with NEMA standard "short shaft" for belt driven loads
Y	Non-NEMA standard mount; a drawing is required to be sure of dimensions. Can indicate a special base, face or flange.
Z	Non-NEMA standard shaft; a drawing is required to be sure of dimensions.

For further standard designations refer to NEMA MG 1- 11.01.

19:
NEMA DESIGN LETTER

Changes in motor windings and rotor design will alter the performance characteristics of induction motors. To obtain uniformity in application, NEMA has designated specific designs of general purpose motors having specified locked rotor torque, breakdown torque, slip, starting current, or other values.

There are standard definitions for designs A, B, C and D. The letter designation describes the torque and current characteristics of the motor.

NEMA Design A motors have normal starting torques, but high starting currents. This is useful for applications with brief heavy overloads. Injection molding machines are a good application for this type of motor.

NEMA Design B motors are the most common. They feature normal starting torque combined with a low starting current. These motors have sufficient locked rotor torques to start a wide variety of industrial applications.

NEMA Design C motors have high starting torques with low starting currents. They are designed for starting heavy loads due to their high locked rotor torques and high full load slip.

NEMA Design D motors have high starting torque and low starting current, however they feature high slip. This reduces power peaks in the event that peak power is encountered, motor slip will increase.

20:
ENCLOSURE TYPE

This designation, often shown as "ENCL" on a nameplate, classifies the motor as to its degree of protection from its environment, and its method of cooling.

Motors are typically supplied in:

Open Drip Proof (ODP): Allows air to circulate through the windings for cooling, but prevent drops of liquid from falling into motor within a 15 degree angle from vertical. Typically used for indoor applications in relatively clean, dry locations.

Totally Enclosed Fan Cooled (TEFC): No airflow through the motor. It has a fan blowing air over the outside of the enclosure to aid in cooling. This motor is not air or water-tight. Outside air and moisture can enter the motor, but not in enough quantities to interfere with normal operation. Typically used for outdoor and dirty locations.

Totally Enclosed Non-Ventilated (TENV): Similar to a TEFC, but has no cooling fan and relies on convention for cooling. No vent openings, tightly enclosed to prevent the free exchange of air, but not airtight. These are suitable for uses which are exposed to dirt or dampness, but not very moist or hazardous (explosive) locations.

Totally Enclosed Air Over (TEAO): Dust-tight fan and blower duty motors designed for shaft mounted fans or belt driven fans. The motor must be mounted within the airflow of the fan.

Totally Enclosed Wash down (TEWD): Designed to withstand high pressure wash-downs or other high humidity or wet environments. Available on TEAO, TEFC and TENV enclosures

Totally enclosed, hostile and severe environment motors: Designed for use in extremely moist or chemical environments, but not for hazardous locations.

Explosion-proof enclosures (EXPL): The motor is designed to withstand an internal explosion of specified gases or vapors, and not allow the internal flame or explosion to escape. Available on TEFC or TENV enclosures

Hazardous Location (HAZ): For use in various hazardous locations, as defined by the National Electric Code (NFPA-70). The only indication that the motor is suitable for the hazardous atmosphere is a UL label indicating the atmosphere in which the motor may be applied, and a temperature code designation. The following hazardous locations are defined:

1) ***CLASS I***

- Group A: Acetylene
- Group B: Butadiene, ethylene oxide, hydrogen, propylene oxide, manufactured gases containing more than 30ydrogen by volume.
- Group C: Acetaldehyde, cyclopropane, diethyl ether, ethylene.
- Group D: Acetone, acrylonitrile, ammonia, benzene, butane, ethanol, ethylene dichloride, gasoline, hexane, isoprene, methane (natural gas), methanol, naphtha, propane, propylene, styrene, toluene, vinyl acetate, vinyl chloride, xylene.

2) ***CLASS II***

- Group E: Aluminum, magnesium, and other metal dusts with similar characteristics.
- Group F: Carbon black, coke or coal dust.
- Group G: Flour, starch or grain dust.

3) ***CLASS III***

- Easily ignitable fibers, such as rayon, cotton, sisal, hemp, cocoa fiber, oakum, excelsior and other materials of similar nature.

The NEMA enclosure description is similar to the IEC Index of Protection (IP) code. The NEMA designations are more descriptive and general, whereas the IEC IP codes are more precise and narrowly defined by a 2-digit code, with the first digit defining how well protected the motor is from solid objects and the second digit describing how well protected the motor is from moister. For example, a NEMA "Open Drip Proof (ODP)" motor corresponds to an IP22 and a NEMA "Totally Enclosed" motor corresponds to an IP54, a NEMA "Weather-Proof" motor to an IP45, and a NEMA "Wash-Down" motor to an IP55.

 # 21:
THERMAL PROTECTION

Thermal protection describes the motors over temperature protection, if so equipped. Thermal protection can include the following:

Auto (Automatic Reset): Contains temperature-sensing device that disconnects one leg of its power source if temperature becomes excessive due to failure-to-start or overload. After motor cools, thermal protector automatically restores power. Should not be used where unexpected re-starting would be hazardous

Imp (Impedance): Motor is designed so that it will not burn out in less than 15 days under locked rotor (stalled) conditions, in accordance with UL standard No. 519.

Man (Manual Reset): Contains a temperature-sensing device that disconnects one leg of its power source if temperature becomes excessive due to failure-to-start or overload. After motor cools, an external button must be pushed to restore power to the motor. Turn off power prior to attempting to reset motor protector. Preferred where unexpected re-starting would be hazardous, as on saws, conveyors, compressors, etc

None: Motor contains no temperature-sensing device to protect motor from excessive temperature due to failure-to-start or overload. Motor should be protected by other means in accordance with the NEC and local code requirements.

T-St (Thermostat): A temperature-sensing device installed inside the motor with separate leads brought out for connection into motor starter pilot circuit. Under failure-to-start or overload conditions, thermostat contacts will open. Thermostat contacts will reclose automatically when motor cools.

Other data

A typical nameplate also includes the motor's brand name, and it includes a "Serial No." or other identifying number unique to that motor, that would let the manufacturer trace the motor back through manufacturing. The nameplate also includes the manufacturer's name, and its principal city and state and "Made in U.S.A." if U.S.-made.

Bearings (optional)

Though NEMA does not require it, many manufacturers supply nameplate data on bearings. Many special bearings are applied in motors for reasons such as high speed, high temperature, high thrust, or low noise. It pays to understand your motors' bearing requirements. The main types are:

Sleeve: Preferred where low noise level and low cost is important, as on fan and blower motors.

Ball: Where higher load capacity and/or less frequent lubrication is desired. Ball bearings are pre-lubricated and protected to keep out contaminants.

Ball & Sleeve: Ball bearing on shaft end, sleeve on terminal box end.

Roller: For rolling-element bearings, the most common is the "AFBMA Number." That is the number that identifies the bearing by standards of the Anti-Friction Bearing Manufacturers Association.

Shaft Type (optional)

This describes the output shaft. The general shaft types include:

Flat: Usually found on motors with up to 1/2" diameter shaft. A length of flat is governed by NEMA standards. Balance of shaft is round.

Key: Primarily used on motors with 5/8" and larger shaft diameter. Key size is determined by NEMA standards.

Round: Used on small C-frame shaded pole motors. Full length of shaft is round.

Thd (Threaded): Used on uni-directional motors for special applications such as driving impeller of jet pumps. Threaded in opposite direction to shaft rotation so driven device tightens on shaft.

Others are available for specific applications.

Mounting (optional)

This describes the method of mounting the motor. Unless specified otherwise, motors can be mounted in any position or any angle. However, unless a drip cover is used for shaft-up or shaft-down applications, drip-proof motors must be mounted in the horizontal or sidewall position to meet the enclosure definition. Mount motors securely to the mounting base of equipment or to a rigid, flat surface, preferably metallic.

The basic types of mount include:

Rigid base: Motor is provided with base which is either welded, bolted or cast on main frame and allows motor to be rigidly mounted on equipment.

Resilient base: A base which is isolated from motor shell with vibration-absorbing material, such as rubber rings. A conductor is imbedded in the ring to complete the circuit for grounding purposes.

NEMA C face mount: Is a machined face with a pilot on the shaft end which allows direct mounting with a pump or other direct coupled equipment. Bolts pass through mounted part to threaded hole in the motor face. Commonly used on jet pumps, oil burners and gear reducers. The mounting dimensions are based on industry (NEMA) standards.

NEMA D flange mount: Is a machined flange with rabbet for mountings. Bolts pass through motor flange to a threaded hole in the mounted part.

Type M or N mount: Has special flange for direct attachment to fuel atomizing pump on an oil burner. In recent years, this type of mounting has become widely used on auger drives in poultry feeders.

Extended through-bolt: Have bolts protruding from the front or rear of the motor by which the driven load is mounted. This is usually used in applications involving small direct drive fans or blowers.

Positioning of studs or bolts do not relate to an industry standard, but will usually be common for a given motor diameter. When replacing motor, on-center distance of studs or bolts should be checked.

Holes: Threaded holes are machined into motor and are usually located on shaft end. Hole positions do not relate to an industry standard, but motors intended for specific applications will usually have the same hole patterns. When replacing a motor, the on-center dimensions of holes should be checked.

Yoke: Tabs are welded to bottom of motor shell for bolting to a fan column or bracket. Used on fan-duty motors only.

Hub: A mounting ring on shaft end of motor. Designed to fit specific applications, such as carbonator pumps and pedestal sump pumps.

Power Factor Correction (Max Corr KVAR) (Optional)

If given, this is the maximum power factor correcting capacitor size to be used. Value is typically given in kVARs. Using higher values than specified could result in higher voltages which could damage the motor or other components.

Special markings

Many motor nameplates have special markings to reflect third-party certification or recognition.

Some common markings are:

CSA (Canadian Standards Association): CSA indicates that the manufacturing system and the motor components meet the standards of, and are continually reviewed by the Canadian Standards Association.

UL (Underwriters Laboratories): UL indicates that the manufacturing system and the motor components meet the standards of, and are continually reviewed by, Underwriters Laboratories.

ASD (Adjustable Speed Drive): A growing area of nameplate marking relates to capabilities of a motor when used on an adjustable speed drive. Many standard motors are applied to adjustable speed drives (ASDs) using general rules of thumb, without the motor manufacturer even knowing of the application. However, given the proper information about the ASD and application, a motor manufacturer can design a motor, or properly apply an existing design, and stamp the approved parameters on the nameplate. This stamping is always required on UL-listed explosion-proof motors.

NEMA V/s IEC standards

The International Electrotechnical Commission (IEC) is the international counterpart to the North American- National Electrical Manufacturers Association (NEMA) standards.

The NEMA and IEC standards use different terms, but they are essentially analogous in ratings and, for most common applications, are largely interchangeable. In brief NEMA standards tend to be more conservative while IEC standards tend to be more specific and more categorized.

Now that we understand the NEMA motor terminology, here's a primer on the most common designations of IEC and how they relate to NEMA standards.

Frame relationships

Both IEC and NEMA motors use a letter code to specify the physical frame dimensions, but the codes are different.

The frame designation for IEC motors is composed of a two-part letter/number code. The letter portion of the code specifies the physical frame dimensions, while the number portion of the code specifies the general frame size.

The letters can get especially tricky, for example, a "K" code for an IEC motor is equivalent to a NEMA "H", whereas an IEC "H" is equivalent to a NEMA "D".

The numeric portion of the code (indicating frame size) is less confusing and there is less overlap for instance an IEC "56" is for sub-fractional motors whereas a NEMA "56 is from ¼ - 1.5 HP motors).

The IEC also defines a motor's mounting position and connecting flange type by a code. A couple of the more common mounting position codes include B3 for foot mounted and B5 for footless. Three different flange types are defined: FF, FT and FI flanges. The FF flange has through bolt holes, and is available for frame sizes from 56 to 280. The FT flange has threaded bolt holes and is also available for frame sizes from 56 to 280.

Note that all the IEC dimensions are in metric units.

Enclosure designations

Like NEMA, IEC has designations indicating the protection provided by a motor's enclosure. However, where NEMA designations are in words, such as Open Drip Proof or Totally Enclosed Fan Cooled, the IEC uses a two-digit "Index of Protection" code to describe how well the enclosure protects the motor from the environment. The first digit indicates how well protected the motor is against the entry of solid objects, the second digit refers to water entry. The two digit number is followed by letters "IP".

Here's what the first digit means:

0 - No protection

1 - Protection against objects larger than 50mm (about 2 in.) in diameter, like hands

2 - Protection against objects larger than 12mm (about 1/2 in.) in diameter, like fingers

4 - Protection against objects larger than 1mm (about 0.04 in.) in diameter, like small tools and wires

5 - Complete protection, including dust-tightness.

The second digit signifies protection against water entry. Here are those ratings:

0 - No protection

1 - Protected from water falling straight down

2 - Protected from water falling as much as 15 deg from vertical

3 - Protected from spraying water as much as 60 deg from the vertical

4 - Protected from splashing water coming from any direction

5 - Protected against jets of water from all directions

6 - Protected from heavy seas

7 - Protected against the effects of immersion to depths of between 0.15 and 1.0m

8 - Protected against the effects of prolonged immersion at depth

By way of general comparison, the NEMA designations are more descriptive and general, whereas the IEC IP codes are more precise and narrowly defined. For most industrial application, an IP 22 relates to open drip-proof motors, IP44 or IP54 to totally enclosed, IP45 to weatherproof, and IP55 to 'washdown-duty motors. For explosion proof motors, the hazardous atmospheres defined by national electrical code parallel those with IEC "flame-proof" motors.

Cooling designations

Again, IEC uses a letter and number IC code to designate how a motor is cooled. There is an individual code for just about every type of cooling method, from small fan cooled motors to large liquid cooled motors. The code can get quite complex, up to a four-letter, four-digit code.

A few of the more common “short codes" are shown below:

IC 01- The first digit indicates that there air can flow freely in and out of the motor. The second digit indicates that the airflow is caused by an integral fan, or "self-induced". This corresponds to a standard NEMA open fan-cooled motor because of the internal-fan action.

IC 40 - The first digit means the frame surface (external enclosure) is cooled (i.e. no internal flow). The second digit indicates that cooling by convection only with without a fan action. This corresponds to a NEMA totally enclosed, non-vented (TENV) motor.

IC 41 - The first digit again indicates frame-surface cooling, but the second indicates that airflow over the motor is caused by an integral fan. This corresponds to a NEMA Totally-Enclosed Fan-Cooled (TEFC) motor.

IC 48 - The first digit indicates that the external frame/enclosure surface is cooled (i.e., no internal flow). But the second says that the motor is in the air stream of the driven fan or blower. This corresponds to a NEMA Totally Enclosed, Air-Over motor (TEAO). This relates to uses where the motor is in air stream of the fan or blower it drives, and is thus cooled by fan action.

Thus for most practical purposes, IC 01 relates to a NEMA open design, IC 40 Totally Enclosed Non-Ventilated (TENV), IC 41 to Totally Enclosed Fan Cooled (TEFC), and IC 48 to Totally Enclosed Over (TEAO).

Duty Cycles

The NEMA motors refer to duty cycle in one of two or three terms: continuous, intermittent or special duty (typically expressed in minutes), IEC breaks it into eight ratings:

S1 - Continuous duty: The motor works at a constant load for enough time to reach temperature equilibrium.
S2 - Short-time duty: The motor works at a constant load, but not long enough to reach temperature equilibrium, and the rest periods are long enough for the motor to reach ambient temperature.
S3 - Intermittent periodic duty: Sequential, identical run and rest cycles with constant load. Temperature equilibrium is never reached. Starting current has little effect on temperature rise.
S4 - Intermittent periodic duty with starting: Sequential, identical start, run and rest cycles with constant load. Temperature equilibrium is not reached, but starting current affects temperature rise.
S5 - Intermittent periodic duty with electric braking: Sequential, identical cycles of starting, running at constant load and running with no load. No rest periods.
S6 - Continuous operation with intermittent load: Sequential, identical cycles of running with constant load and running with no load. No rest periods.
S7 - Continuous operation with electric braking: Sequential identical cycles of starting, running at constant load and electric braking. No rest periods.
S8 - Continuous operation with periodic changes in load and speed: Sequential, identical duty cycles run at constant load and given speed, and then run at other constant loads and speeds. No rest periods.

Design Types

The IEC design rating code describes a motor's speed vs. torque characteristics. The IEC Design codes nearly mirror NEMA Design Types, but with different letters. For example, the most common industrial motor is an IEC Design N motors, which is very similar to a NEMA Design B motor- the most common type of motor for industrial applications. By the same token, the characteristics of IEC Design H are nearly identical to those of NEMA Design C. There is no specific IEC equivalent to NEMA Design D.

Logically the suffix with IEC has a meaning. Say comparing toques of IEC Design N *(think of it as "normal" torque)* motors in general mirror those of NEMA Design B motors. The torque of IEC Design H *(think of it as "high" torque)* is nearly identical to those of NEMA Design C.

Insulation designations

IEC and NEMA use the same classification system for winding insulation. It is based on the highest temperature the material can withstand continuously without degrading or reducing motor life. The table below compares temperature rises (add 45°C for total acceptable temperature), allowed under IEC and NEMA standards.

IEC V/s NEMA Temperature Rise, degrees C			
Insulation Class	**IEC (1.0 Service Factor)**	**NEMA (1.0 Service Factor)**	**NEMA (1.15 service Factor)**
A	60	60	70
E	75	*	*
B	80	80	90
F	100	105	115
H	125	125	-

*Note that NEMA has no Class E.

Most industrial-duty motors use Class B or Class F insulation, depending on the application. IEC and NEMA 1.00 service factor ratings are nearly identical; NEMA 1.15 ratings are higher.

Kilowatts & horsepower

The rated shaft power output at the rated voltage, current and frequency. IEC uses kilowatts (kW) and NEMA uses horsepower (hp). The conversion between the two is 1hp = 745.7 W = 0.7457kW

And like NEMA, IEC assigns comparable power ratings to standard frame sizes.

IEC and NEMA kW/hp comparisons flows smoothly in smaller ratings, but in larger sizes they can vary enough to cause concern in some design applications. An example is IEC 115S/NEMA364T areas for 4-pole motors. Here, NEMA calls for 75 hp in the frame size in which IEC calls for 50 hp. Dropping to a NEMA 326T frame provides the 50 hp needed, if the dimensioning differences can be tolerated. If you need the 364T dimensions, be sure not to damage the drive train or load with the higher-power motor.

Rated Voltage (Volts)

IEC standard 34-1 requires that motors be able to provide their rated output at their rated efficiency for a voltage range of 95% - 105% of the rated voltage.

Efficiency

The efficiency for IEC motors is usually given at full load (□ 100) and at 75% load (□¾). Also, an efficiency rating (EFF1, EFF2, and EFF3) may appear on the motor.

Service Factor (not used for IEC motors)

IEC motors do not have a "Service Factor" rating definition. Instead, the temperature rise, ambient temperature and altitude ratings are defined via the kW output rating. If an increased service factor is required, use the next size larger motor.

That's a short guideline in nameplate terminology and IEC/NEMA comparisons. IEC rating's in general follows a more logical, systematic, and descriptive path than those of NEMA.