Glossary of Motor Terms

AC (Alternating Current):
The commonly available electric power supplied by an AC generator and is distributed in single or three phase forms. AC current changes its direction of the flow (cycles).

AC Motors:
A motor (see motor definition) operating on a-c current that flows in either direction (AC current) there are two general types: induction, and synchronous.

Active Iron:
The amount of steel (iron) in the stator and rotor of a motor. Usually the amount of active iron is increased or decreased by lengthening or shortening the rotor and stator (they are generally the same length).

Air Gap:
The space between the rotating (rotor) and stationary stator member in an electric motor.

Air Pressure Switch:
Used on motors with blowers to measure the difference in pressure across the filter so as to detect a clogged filter.

Altitude:
The atmospheric altitude (height above sea level) at which the motor will be operating; NEMA standards call for an altitude not exceeding 3,300 ft. (1,000 meters). As the altitude increases above 3,300 ft. And the air density decreases, the air's ability to cool the motor decreases; for higher altitudes, higher grades of insulation or a motor departing are required. DC motors require special brushes for high altitudes.

Ambient Temperature:
The temperature of the surrounding cooling medium, such as gas or liquid, which comes into contact with the heated parts of the motor. The standard enema rating for ambient temperature is not to exceed 40 degrees Celsius.

Anti-Friction Bearing:
An anti-friction bearing is a beating utilizing tolling elements between the stationary and rotating assemblies.

Armature:
The portion of the magnetic structure of a DC or universal motor which rotates.

Armature Current, Amps:
Rated full load armature circuit current.

Armature Inductance, Mho
Armature inductance in mill-henries (saturated).

Armature Reaction:
The current that flows in the armature winding of a d-c motor tends to produce magnetic flux in addition to that produced by the field current. This effect, which reduces the torque capacity, is called armature reaction and can affect the commutation and the magnitude of the motor's generated voltage.

Armature Resistance, Ohms:
Armature resistance is measured in ohms at 25 degrees Celsius. (cold)

Axial Thrust:
The force or loads that are applied to the motor shaft in a direction parallel the axis of the shaft. (such as from a fan or pump)

Back End of a Motor:
The back end of a normal motor is the end which carries the coupling of driving pulley. (NEMA) this is sometimes called the drive end (D.E., pulley end P.E.) etc.

Base End of a Motor:
The speed which a d-c motor develops at rated armature and field voltage with rated load applied.

Bearings:
Are used to reduce friction and wear while supporting rotating elements. For a motor, it must provide a relatively rigid support for the output shaft. The bearing acts as the connection point between the rotating and stationary elements of a motor. There are various types such as roller, ball, sleeve (journal), and needle. The ball bearing is used in virtually all types and sizes of electric motors. It exhibits low friction loss, is suited for high speed operation and is compatible in a wide range of temperatures. There are various types of ball bearings such as open, single shielded or sealed.

Bearing Life:
Rating life is the life in hours or revolutions in which 90% of the bearings selected will obtain or exceed. Median life (average life) is the life in hours or revolutions in which 50% of the bearings selected will obtain or exceed.

Brake:
An external device or accessory that brings a running motor to a standstill and/or holds a load. Can be added to a motor or incorporated.

Braking Torque:
The torque required to bring a motor down to a standstill. The term is also used to describe the torque developed by a motor during dynamic braking conditions.

Breakdown Torque:
The maximum torque a motor will develop at rated voltage without a relatively abrupt drop or loss in speed.

Brush:
A piece of current conducting material (usually carbon or graphite) which rides directly on the commentator of a committed motor and conducts current from the power supply to the armature windings.

“C” Flange:
A type of flange used with close coupled pumps, speed reducers, and similar applications where the mounting holes in the flange are threaded to receive bolts.
Normally the “C” flange is used where a pump or similar item is to be overhung on the motor. The “C” type flange is a NEMA standard design and available with or without feet.

Canopy (Dripcover):
A protective cover placed on the top of a motor being mounted vertically to protect it from liquids or solids that might drop onto the motor. (It acts similar to an umbrella for the motor.)

Capacitor:
A device which, when connected in an alternating- current in an alternating-current circuit, causes the current to lead the voltage in time phase. The peak of the current wave is reached ahead of the peak of the voltage wave. This is the result of the successive storage and discharge of electric energy used in 1 phase motors to start or in 3 phase for power factor correction.

Capacitor Motor:
A single-phase induction motor with a main winding arranged for direct connection to the power source, and auxiliary winding connected in series with a capacitor. There are three types of capacitor motors: capacitor- start, in which the capacitor phase is in the circuit only during starting, permanent-split capacitor and capacitor phase in the circuit for both starting and running, two- value capacitor motor, in which there are different values of capacitance for starting and running.

Capacitor Start:
The capacitor start single phase motor is basically the same as the split phase start, except that it has a capacitor in series with the starting winding. The addition of the capacitor provides a more ideal phase relation and results in greater starting torque with much less power input. As in the case of the split phase motor, this type can be reversed at rest, but not while running unless special starting and reversing switches are used. When properly equipped for reversing while running, the motor is much more suitable for this service than the split phase start as it provides greater reversing ability at less watts input.

Centrifugal Cutout Switch:
A centrifugally operated automatic mechanism used in conjunction with split phase and other types of single phase induction motors. Centrifugal cutout switches will open or disconnect the starting winding when the rotor has reached a pre-determined speed, and reconnect it when the motor speed falls below it. Without such a device, the starting winding would be susceptible to rapid overheating and subsequent burnout.

Clutch:
A mechanical device for engaging and disengaging a motor often used when many starts and stops are required.

Conductor:
A material, such as cooper or aluminum, which offers low resistance or opposition to the flow of electric current.

Conduit Box:
The metal container usually on the side of the motor where the stator (winding) leads are attached to leads going to the power supply.

Cogging:
A term used to describe non-uniform angular velocity. It refers to rotation occurring in jerks or increments rather than smooth motion. When an armature coil enters the magnetic field produced by the field coil, it tends to speed up and slow down when leaving it this effect becomes apparent at low speeds. The fewer the number of coils, the more noticeable it can be.

Coil (Stator or Armature):
The electrical conductors wound into the core slot, electrically insulated from the iron core. These coils are connected into circuits or windings which carry independent current. It is these coils that carry and produce the magnetic field when the current passes through them. There are two major types: “mush” or “random” wound, round wire found in smaller and medium motors where coils are randomly laid in slot of stator core; and formed coils of square wire individually laid in, one on top of the other, to give an evenly stacked layered appearance.

Commutator:
A cylindrical device mounted on the armature shaft and consisting for a number of wedge-shaped copper segments arranged around the shaft (insulated from it and each other). The motor brushes ride on the periphery of the commutator and electrically connect and switch the armature coils to the power source.

Compound Wound DC Motors:
Designed with both a series and shunt field winding, the compound motor is used where the primary load requirement is heavy starting torque, and adjustable speed is not required. (see “Paralleling”) also used for parallel operation. The load must tolerate a speed variation from full -load to no-load. Industrial machine applications include large planers, boring mills, punch presses, elevators, and small hoists.

Constant HP:
A designation for variable or adjustable speed motors used for loads requiring the same amount of HP. regardless of their motor speed during normal operation.

Core:
The iron portion of the stator and rotor; made up of cylindrical laminated electric steel. The stator and rotor cores are concentric separated by an air gap, with the rotor core being the smaller of the two and inside to the stator core.

Counter Electromotive Force (CEMF):
The induced voltage in a motor armature, caused by conductors moving through or "cutting" field magnetic flux. This induced voltage opposes the armature current and tends to reduce it.

Couplings:
The mechanical connector joining the motor shaft to the equipment to be driven.

Current:
The time rate of flow of electrical charge and is measured in amps (amperes).

Cycles Per Second (Hertz):
One complete reverse of flow of alternating current per rate of time (a measure of frequency.) 60 Hz (cycles per second) AC. power is common throughout the U.S. and 50 Hz is more common in some foreign countries.

"D" Flange:
A special end shield with holes for through bolts in the flange and is primarily used for mounting the motor on gear boxes or bulkheads. Standardized for frames 143t through 445t. "D" flanges are not threaded and the bolt holes extend beyond the motor frame.

DC (Direct Current):
A current that flows only in one direction in an electric circuit. It may be continuous or discontinuous and it may be constant or varying.

DC Motor:
A motor using either generated or rectified DC. power (see motor definition). A DC motor is usually used when variable speed operation is required.

Design A, B, C, D- For AC Motor:
NEMA has standard NEMA motor designs of various torque characteristics to meet the various requirements posed by different application loads. The design "B" is the most common design. (see chart for characteristics of each design).

NEMA Design	starting torque	starting current	break down torque	full load slip	typical application
A	normal	high	high		mach.tools fans
B	normal	normal	high	low	same as "A"
C	high	normal	normal	normal	loaded compressor, conveyor
D	very high	low	low	normal	punch press

Dimensions:
NEMA has standard frame sizes and dimensions designating the height of the shaft, the distance between mounting bolt holes and various other measurements. The integral AC motor NEMA sizes run from 143t-445t, and the center of the shaft height in inches can be figured by taking the first two digits of the frame number and dividing it by 4. The fractional horsepower motors, for which NEMA spells out dimensions, utilize 42, 48 and 56 frames whose shaft height in inches is figured by dividing the frame number by 16.

Drip-Proof Guarded:
A drip-proof machine with ventilating openings are so constructed that drops of liquid or solid particles falling on it, at any angle not greater than 15 degrees from the vertical, cannot enter either directly or by striking and running along a horizontal or inwardly inclined surface.

Dual Torque:
Dual speed motor whose torque varies with speed (as the speed changes the horsepower remains constant).

Definite Purpose Motor:
A definite purpose motor is any motor design, listed and offered in standard ratings with standard operating characteristics with special mechanical features for use under service conditions other than usual or for use on particular type of application. (NEMA)

Dual Voltage:
Some motors can operate on two different voltages, depending upon how it is built and connected.

Dynamometer:
A device which loads the motor to measure output torque and speed accurately by providing a calibrated dynamic load. Helpful in testing motors for nameplate information and an effective device in measuring efficiency.

Eddy Current:
Localized currents induced in an iron core by alternating magnetic flux. These currents translate into losses (heat) and their minimization is an important factor in lamination design.

Efficiency:
The efficiency of a motor is the ratio of mechanical output to electrical input. It represents the effectiveness with which the motor converts electrical energy into mechanical energy. NEMA has set up codes which correlate to specific nominal efficiencies. A decrease in losses (the elements keeping the motor from being 100% efficient) of 10% constitutes an upward improvement of the motor of one codes the NEMA table. Each nominal efficiency has a corresponding minimum efficiency number.

Electrical Degree:
A unit of measurement of time as applied to alternating current. One complete cycle 360 electrical degrees. One cycle in a rotating electric machine is accomplished when the rotating field moves from one pole to the next pole of the same polarity. There are 360 electrical in this time period. Therefore, in a two-pole machine there are 360 degrees in one revolution, and the electrical and mechanical degrees are equal. In a machine with more than two poles, the number of electrical degrees per Revolution is obtained by multiplying the number of pairs of poles by 360.

Electrical Time Constant (For DC Motors):
The ratio of electrical inductance to armature resistance. Electrical time constant in seconds defined as electrical

$$T/C = \frac{La \times La}{\text{Hot IR voltage drop}}$$

Where la is the armature circuit inductance's in henries and la is the rated full load armature current.

Electrical Unbalance:
In a 3-phase supply, where the voltages of the three different phases are not exactly the same. Measured in % of unbalance.

Electromotive Force (EMF):
A synonym for voltage of the, usually restricted to generated voltage.

Encapsulated Winding:
A motor which has its winding structure completely coated with structure completely coated with an insulating resin (such as epoxy). This construction type is designed for exposure to more severe atmospheric conditions than the normal varnished winding.

Enclosures:
The housing frame, of the motor of which there are two broad classifications; open and totally closed. There are specific types of each:

- Open
- totally enclosed
- Drip proof non-ventilated
- Splash proof fan cooled
- Weather protected explosion proof
- Weather protected I water proof
- Weather protected II heat exchanger

Endshield:
The part of the motor housing which supports the bearing and acts as a protective guard to the electrical and rotating parts inside the motor. This part is frequently called the “end bracket” or “end bell.”

Explosion-Proof Enclosure:
A totally enclosed which is constructed to withstand and explosion occur, the enclosure will prevent the ignition or explosion of the gas or vapor which may surround the motor enclosure. These motors are listed with underwriter’s laboratories.

Explosion-Proof - Hazardous Locations:
Division I - location in which ignitable concentrations of flammable or combustible material exist and come in contact with the motor.

Division II - location in which ignitable concentrations of flammable or combustible material exist but are contained within closed systems or containers and normally would not come in contact with the motor.

Explosion-Proof - UL Classifications:

- **Class I** - Those in which flammable gasses or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.
- **Group “C”** - Atmospheres containing ethyl or ether vapors.
- **Group “D”** - Atmospheres containing gasoline, hexane, benzene, butane, propane, alcohols, acetone, benzol, lacquer solvent vapors, natural gas, etc.
- **Class II** - Those which are hazardous because of the presence of combustible dust.
- **Group “E”** - Atmospheres containing metal dust, including aluminum, magnesium, or their commercial alloys.
- **Group “F”** - Atmospheres containing carbon black, charcoal or coke dust.
- **Group “G”** - Atmospheres containing flour, starch, grain or combustible plastics or chemical dusts.

Externally ventilated:
A motor using an external cooling system. This is required in applications where the motor’s own fan will not provide sufficient cooling; this is true for certain duty cycle applications, slow speed motors, also in environments with extreme dirt. Often a duct with an external blower is used to bring clean air into the motor’s air-intake.

Field:
A term commonly used to describe the stationary (stator) member of a d-c motor. The field provides the magnetic field with which the mechanically rotating (armature or rotor) member interacts.

Field Weakening:
The introduction of resistance in series with the shunt wound field of a d-c motor to reduce the voltage and current which weakens the strength of the magnetic field and thereby increases the motor speed.

Flange:
Mounting end-shield with special rabbets and bolt holes for mounting such equipment as pumps and gear boxes to the motor or for overhanging the motor on the driven machine.

Flux:
The magnetic field which is established around an energized conductor or permanent magnet. The field is represented by flux lines creating flux pattern between opposite poles. The density of the flux lines is a measure of the strength of the magnetic field.

Form Factor:
A figure of merit which indicates how much rectified current departs from pure (non - pulsating) d-c. A large departure from unity form factor (pure d-c) increases the heating effect of the motor and reduces brush life.
Mathematically, form factor is the ratio of the root-mean- square (rms) value of the current to the average (AV) current or lrms/lav.

Form Wound:
A type of coil in which each winding is individually formed and placed into the stator slot. A cross sectional view of the winding is individually formed and placed into the stator slot. A cross sectional view of the winding would be rectangular. Usually form winding is used on high voltage, 2300 volts and above, and large motors (449t and above). Form winding allows for better insulation on high voltage than does random (mush) winding.

Fractional-Horsepower Motor:
A motor usually built in a frame smaller than having a continuous rating of on horsepower, open construction, at 1700-1800 rpm. Within NEMA frame size FHP encompasses the 42, 48 and 56 frames. (in some cases, the motor rating does exceed 1 hp, but the frame size categorizes the motor as a fractional.) The height in inches from the center of the shaft to the bottom of the base can be calculated by dividing the frames size by 16.

Frame:
The supporting structure for the stator parts of an a-c motor; in a d-c motors frame usually forms a part of the magnetic coil. The frame also determines mounting dimensions (see frame size).

Frame Size:
Refers to a set of physical dimensions of motors as established by NEMA. These dimensions include critical mounting dimensions. 48 and 56 frame motors are considered fractional horsepower sizes even though they can exceed 1 horsepower, 143t to 449t are considered integral horsepower a-c motors and 5000 series and above are called large motors. (for definition of letters following frame number, see suffixes.)

Front End of a Motor:
The front end of a normal motor is the end opposite the coupling or driving pulley. (NEMA) This sometimes called the opposite pulley end (O.P.E.) or commutator end (C. E.).

Full-Load Current:
The current flowing through the line when the motor is operating at full-load torque and full-load torque and full- load speed with rated frequency and voltage applied to the motor terminals.

Full-Load Torque:
That torque of a motor necessary to produce its rated horsepower at full-load speed, sometimes referred to as running torque.

Gearhead:
The portion of a gearmotor combination to reduce the speed of the motor to obtain the desired rpm’s

General Purpose Motor:
A general-purpose motor is any motor having a “b” design, listed and offered in standard ratings with standard operating characteristics and mechanical construction for use under usual service conditions without restriction to a particular application or type of application. NEMA)

Grounded Motor:
A motor with an electrical connection between the motor frame and ground.

Guarded Motor:
An open motor in which all openings giving direct access to live or rotating parts (except smooth shafts) are limited in size by the design of the structural parts or by screens, grills, expanded metal, etc., To prevent accidental contact with such parts. Such openings shall not permit the passage of a cylindrical rod 1/2 inch in diameter.

Heat Exchanger:
A device which will transfer the heat from inside the motor to another medium, through a radiator type heat exchanger.

Hertz (Hz):
One cycle per second (as in 60 cycles per second).

Horsepower:
The measure of rate of work. One horsepower is equivalent to lifting 33,000 pounds to a height of one foot in one minute. The horsepower of a motor is expressed as a function of torque and rpm. For motors, the following approximate formula may be used:

$$HP = \frac{TxRPM}{5250}$$

Where hp horsepower, T = Torque (in lb. ft.), and RPM = Revolutions Per Minute

Hysteresis Loss:
The resistance offered by materials to becoming magnetized (magnetic orientation of molecular structure) results in energy being expended and corresponding loss. Hysteresis loss in a magnetic circuit is the energy expended to magnetize and demagnetize the core.

Identification:
In most instances, the following information will help identify a motor:

1. Frame designation (actual frame size in which the motor is built)
2. Horsepower, speed, design and enclosure
3. Voltage, frequency and number of phases of power supply
4. Class of insulation and time rating
5. Application

Inductance:
The characteristic of an electric circuit by which varying current in it produces a varying magnetic field which causes voltage in the same circuit or in a nearby circuit.

Induction Motor:
An induction motor is an alternating current motor in which the primary winding on one member (usually the stator is connected to the power source and a secondary winding or a squirrel-cage secondary winding on the other member (usually the rotor) carries the induced current. There is no physical electrical connection to the secondary winding, its current is induced.

Inertial Load:
A load (flywheel, fan, etc.) which tends to cause the motor shaft to continue to rotate after the power has been removed (stored kinetic energy). If this continued rotation cannot be tolerated, some mechanical or electrical braking means must normally be applied. This application may require a special motor due to the energy required to accelerated the inertia. Inertia is measured in either lb. $Ft.^2$ or oz. $In.^2$.

$$\text{Inertia reflected to the shaft of the motor} = \frac{(\text{load rpm})^2}{\text{motor rpm}}$$

Insulator:
A material which tends to resist the flow of electric current (paper, glass, etc.) in a motor the insulation servers two basic functions:

1. Separates the various electrical components from one another.
2. It protects itself and the electrical components from attack of contaminants and other destructive forces.

Insulation System:
Five specialized elements are used, which together constitutes the motor's insulation system. The following are typical in an AC motor.

1. Turn-to -turn insulation between separates wires in each coil. (usually enamel on random wound coils of smaller motors - tape on "form-wound" coils of larger motors.)
2. Phase-to-phase insulation between adjacent coils in different phase groups. (a separate sheet material on smaller motors - not required on form wound coils because the tape also performs this function.)
3. Phase-to-ground insulation between windings as a whole and the "ground" or metal parts of the motor. (a sheet material, such as the liner used in stator slots, provides both di-electric and mechanical protection.)
4. Slot wedge to hold conductors firmly in the slot.
5. Impregnation to bind all the other components together and fill in the air spaces. (a total impregnation, applied in a fluid from and hardened, provides protection against contaminants.

Insulation Class:
Since there are various ambient temperature conditions a motor might see and different temperature ranges within which motors run and insulation is sensitive to temperature; motor insulation is classified by the temperature ranges at which it can operate for a sustained period of time. There are four common classes:

AC. Motor w/1.00 S. F. max. Total temperature range class (including ambient and 10-degree hot spot)		DC motor total temperature range	
A	105C	A	110C
B	130C	B	140C
F	155C	F	170C
H	180C	H	195C

When a motor insulation class is labeled on the nameplate the total insulation system is capable of sustained operation at the above temperature.

Intermittent Duty:
A requirement of services that demands operation for alternate intervals of (1) load and no load; or (2) load and rest; or (3) load, no load and rest; such alternate intervals being definitely specified.

Interpoles:
An auxiliary set of field poles carrying armature current to reduce the field flux caused by armature reaction in a DC motor.

Inverter:
An electronic device that converts fixed voltage to variable frequency and voltage. Enables the user to electrically vary the speed of an AC motor.

J Seconds (DC Motors):
J is the per unit moment of inertia. It is defined as the time in seconds to accelerate the motor armature to rated base speed using rated full load torque.

$$J = Wr^2 \text{ X Base Rpm (Seconds) } 308 \text{ X Rated Torque}$$

Jackscrew:
A device used for leveling the positioning of a motor. These devices are adjustable screws fitting on the base or motor frame. Also, a device for removing endshields from a motor assembly.

Kilowatt:
Since the watt is a relatively small unit of power, the kilowatt (kW) 1,000 watts, is used where larger units of power measurements are desirable.

Laminations:
The steel portion of the rotor and stator cores made up of a series of thin laminations (sheets) which are stacked and fastened together by cleats, rivets or welds. Laminations are used instead of a solid piece in order to reduce eddy-current losses.

Large Motors:
Usually refers to a-c motors in 5,000 series frames and above. 500 series frames and larger in DC.

Load:
The burden imposed on a motor by the driven machine. It is often stated as the torque required to overcome the resistance of the machine it drives. Sometimes “load” is synonymous with “required power.”

Locked Rotor Current:
Steady state current taken from the line with the rotor at standstill (at rated voltage and frequency). This is the current seen when starting the motor and load.

Locked Rotor Torque:
The minimum torque that a motor will develop at rest for all angular positions of the rotor (with rated voltage applied at rated frequency).

Losses:
A motor converts electrical energy into a mechanical energy and in so doing, encounters losses. These losses are all the energy that is put into a motor and not transformed to usable power but are converted into heat causing the temperature of the windings and other motor parts to rise.

Lubrication:
In order to reduce wear and avoid overheating certain motor components require lubricating (application of an oil or grease). The bearings are the major motor components requiring lubrication (as per manufacturer’s instructions). Excess greasing can however damage the windings and internal switches, etc.

Magnetic Polarity:
It is a fundamental principle of a winding that adjacent poles must be wound to give opposite magnetic polarity. This does not mean that the coils actually have to be wound in this direction before being placed into the stator. It does mean that the winding must be connected so that, if the current proceeds through the next pole in a counterclockwise direction. This principle is used to determine the correctness of connection diagrams.

Medium Motors:
Motors in NEMA 143T to 449T frames.

Meggar Test:
A measure of an insulation system’s resistance. This is usually measured in megohms and tested by passing a high voltage at low current through the motor windings and measuring the resistance of the various insulation systems.

Motor:
A device that takes electrical energy and converts it into mechanical energy to turn a shaft.

Multi-Speed Motors:
A motor wound in such a way that varying connections at the starter can change the speed to a predetermined speed. The most common multi-speed motor is a two speed although three- and four speeds are sometimes available. Multi-speed motors can be wound with two sets of winding or one winding. They are also available either constant torque, variable torque or constant horsepower.

Nameplate:
The plate on the outside of the motor describing the motor, hp, voltage, rpm's, efficiency, design, enclosure, etc.

Navy Service "A":
Motors designed to meet requirements of MIL M - 17059 or MIL M - 17060 for high shock and service and are essential to the combat effectiveness of a ship.
These motors are usually made of nodular iron.

NEMA:
The national electrical manufactures association is a non-profit organization organized and supported by manufacturers of electric equipment and supplies.

NEMA has set standards on:
HP ratings speeds
frame sizes and dimensions
standard voltage and frequencies with allowable variations
service factors torque
starting current & KVA enclosures

NEMA I:
See weather protected machine, type I

NEMA II:
See weather protected machine, type II

Nodular Iron (Ductile Iron):
Special cast iron with a crystalline formation which makes it capable of handling high shock.

Oil Mist Lubrication-Dry Sump:
A method for lubricating anti-friction bearings which utilizes oil dispersed on an air stream. The mist is exhausted from the bearing housing so as not to permit oil to accumulate.

Oil Mist Lubrication-Wet Sump:
Similar to oil mist lubrication - dry sump, except that a pool of oil is developed in the bearing chamber. This oil pool will continue to supply.

Open Bearings:
A ball bearing that does not have a shield, seal or guard on either of the two sides of the bearing casing.

Open Externally-Ventilated Machine:
An open machine except that openings for admission of ventilating air so arranged that inlet ducts or pipes can be connected to them. Air may be circulated by means integral with machine or by means external to and note a part of the machine. In the latter case, this machine is sometimes known as separately- of force-ventilated machine.

Open (Protected) Motor:
A motor having ventilating openings which permit passage of external cooling air over and around the windings. The term "open machine", when applied to large apparatus without qualification, designates a machine having no restriction to ventilation other than that necessitated by mechanical construction.

“P” Base:
A special mounting similar to “D” flange except with a machine fit tenon recessed instead of protruding. Usually found on pumps.

Paralleling:
When two or more d-c motors are required to operate in parallel- that is, to drive a common load while sharing the load equally among all motors- they should have speed-torque characteristics which are identical. The greater the speed droop with load, the easier it becomes to parallel motors successfully. It follows that series motors will operate in parallel easier than any other type. Compound motors, which also have drooping speed characteristics (high regulation), will generally parallel without special circuits or equalization. It may be difficult to operate shunt or stabilized-shunt motors in parallel because of their nearly constant speed characteristics. Modifications the motor control must sometimes be made before these motors will parallel within satisfactory limits.

Part Winding Start Motor:
Is arranged for starting by first energizing part of the primary winding and subsequently energizing the remainder of this winding in one or more steps. The purpose is to reduce the initial value of the starting current drawn or the starting torque developed by the motor. A standard part winding start induction motor is arranged so that one-half of its primary winding can be energized initially and subsequently the remaining half can be energized, both halves than carrying the same current.

Permanent Magnet Synchronous (PMR) (Hysteresis Synchronous):
A motor with magnets embedded into the rotor assembly, which enable the rotor to align itself with the rotating magnetic field of the stator. These motors have zero slip (constant speed with load) and provide higher torque, efficiency and draw less current than comparable reluctance synchronous motors synchronous motors.

Phase:
Indicates the space relationships of winding and changing values of the recurring cycles of a. C. Voltage and currents. Due to the positioning (or the phase relationship) of the windings, the various voltages and currents will not be similar in all aspects at any given instant. Each winding will lead or lag another voltage, in time. Each current will lead or lag another current, in time. The most common power supplies are either single (1) or three phase (with 120 electrical degrees between the 3 phase).

Plug Reversal:
Reconnecting a motor’s winding in reverse to apply a reverse braking torque to its normal direction of rotation while running. Although it is an effective dynamic braking means in many applications, plugging produces more heat than other methods and should be used with cautions.

Polarization Test:
A ratio of a one-minute meggar test (see meggar test) to ten-minute meggar test. Used to detect contaminants in winding insulation done typically on high voltage.

Poles:
In an AC motor, refers to the number of magnetic poles in the stator winding. The number of poles is determinant of the motor’s speed. (see synchronous speed) In a DC motor, refers to the number of magnetic poles in the motor. Creates the magnetic field in which the armature operates. (speed is not determined by the number of poles).

Polyphase Motor:
Two or three phase induction motors have their windings, one of each phase, evenly divided by the same number of electrical degrees. Reversal of the two- phase motor is accomplished by reversing the current through either winding. Reversal of a three-phase motor is accomplished by interchanging any two of its connections to the line. Polyphase motors are used where a polyphase (3-phase) power supply is available and is limited primarily to industrial applications. Starting and reversing torque characteristics of poly-phase motors are exceptionally good. This is due to the fact that the different windings are identical and, unlike the capacitor motor, the currents are balanced. They have an ideal phase relation which results in a true rotating field over the full range of operation from locked rotor to full speed.

Power Code:
Identifies the type of power supply providing power to a d-c motor. Frequency, voltage, and type of rectifier configuration.

Power Factor:
A measurement of the times phase difference between the voltage and current in an a-c circuit. It is represented by the cosine of the angle of this phase difference. For an angle of 0 degrees, the power factor is 100% and the volt/amperes of the circuit are equal to the watts. (this is the ideal and an unrealistic situation.) Power factor is the ratio of real power-kW to total KVA or the ratio of actual power (watts) to apparent power (volts-amperes).

Primary Winding:
That winding of a motor, transformer or other electrical device which is connected to the power source.

Protective Relay:
A relay, the principal function of which is to protect service from interruption, or to prevent or limit damage to apparatus.

Pull-In Torque:
The maximum constant torque which a synchronous motor will accelerate into synchronism at rated voltage and frequency.

Pull-Up Torque:
The minimum torque developed by an a-c motor during the period of acceleration from zero to the speed at which breakdown occurs. For motors which do not have a definite breakdown occurs. For motors which do not have a definite breakdown torque, the pull-up torque is the minimum torque developed during the process of getting up to the rated speed.

R-R (r bar) is the per unit armature circuit resistance using counter emf as a base.

$$\frac{\text{R= hot IR voltage drop}}{\text{Terminal volts - (Hot IR voltage drop)}}$$

Hot IR voltage drop = (rated I_a x Hot Arm. Cir. Resistance) + 2.0 (Brush drop) volts.

R. P. M. (Revolutions Per Minute):
The number of times per minute the shaft of the motor (machine) rotates. This is a function of design and the power supply.

Random Wound:
The standard type of stator winding used in motors under 1,000 volts. The coils are random wound with round wire as opposed to flat form wound coils.

RTD (Resistance Thermal Detectors):
Winding RTD - resistance device used to measure temperature change in the motor windings to detect a possible overheating condition. These detectors would be embedded into the winding slot and their resistance varies with the temperature.
Bearing RTD - probe used to measure bearing temperature to detect an overheating condition. The RTD's resistance varies with the temperature of the bearings.

Reactance (Inductive):
The characteristic of a coil, when connected to alternating current, which causes the current to lag the voltage in time phase. The current wave reaches its peak later than the voltage wave reaches its peak.

Relay:
A device that is operation by a variation in the conditions of one electric circuit to affect the operation of other devices in the same or another electric circuit.

Reluctance:
The characteristic of a magnetic material which resists the flow of magnetic lines of force through it.

Reluctance Synchronous Motor:
A synchronous motor with a special rotor design which directly lines the rotor up with the rotating magnetic field of the stator, allowing for no slip under load. The reluctance motors have lower efficiencies, power factors and torque than their per than their permanent magnet counterparts.

Resistance:
The degree of obstacle presented by a material to the flow of electric current is known as resistance and is measured in ohms.

Resilient Mounting:
A suspension system or cushioned mounting designed to reduce the transmission of normal motor noise and vibration to the mounting surface. This type of mounting is typically used in fractional used in fractional motors for fans and blowers.

Reversing:
Unless otherwise specified, a general-purpose d-c motor is reversible. A d-c motor can be reversed by changing the polarity of the field or the armature, but not both. When rapid reversing is necessary, the armature circuit is reversed. In some cases, it is frequently more advantageous to reverse the field connections of shunt motors, since the controls have to handle much less current, especially on large motors, than do armature- circuit connections of one leg on three-phase power or by reversing the leads on single phase.

Roller Bearing:
A special bearing system with cylindrical rollers capable of handling belted applications, too large for standard ball bearings.

Rotating Magnetic Field:
The force created by the stator once power is applied to it that causes the rotor to turn.

Rotor:
The rotating member of an induction motor made up of stacked laminations. A shaft running through the center and a squirrel-cage made in most cases of aluminum which holds the laminations together and act as a conductor for the induced magnetic field. The squirrel cage is made by casting molten aluminum into the slots cut into each lamination.

Screens:
Are protection which can be placed over openings in the fan cover on a fan-cooled motor or ventilation openings of a protected motor to help keep out large particles and/or animals, but not block ventilation.

Secondary Winding:
Winding which is not connected to the power source, but which carries current induced in it through its magnetic linkage with the primary winding.

Series DC Winding:
Where high starting torque are required for a d-c motor, the series motor is used. The load must be solidly connected to the motor and never decrease to zero to prevent excessive motor speeds. The load must tolerate wide speed variations from full load to light load. Typical areas of application are industrial trucks, hoists, cranes, and traction duty.

Service Factor:

1. When used on a motor nameplate, a number which indicates how much above the nameplate rating a motor can be loaded without causing serious degradation, (i.e., A 1.15 S-F can produce 15% greater torque than the 1.0 S-F rating of the same motor).
2. When used in applying motors or gearmotors, a figure of merit which is used to “adjust” measured loads in an attempt to compensate for conditions which are difficult to measure or define. Typically, measured loads are multiplied by service factors (experience factors) and the result in an “equivalent required torque” rating of a motor or gearmotor.

Short- Circuit:
A defect in a winding which causes part of the normal electrical circuit to be bypassed. This frequently results in reducing the resistance or impedance to such an extent as to cause overheating of the winding, and subsequent burnout.

Shaft:
The rotating member of the motor which protrudes past the bearings for attachment to the driven apparatus.

Shunt Wound DC Motors:

Integral-horsepower shunt motors, are used where the primary load requirements are for minimum speed variation from full-load to no-load and/or constant horsepower over an adjustable speed range at constant potential. Shunt motors are suitable for average starting torque loads. Typical applications include individual drives for machine tools, such as drills and lathes, and centrifugal fans and blowers which are regulated by means of the discharge opening.

Skew:
Arrangement of laminations on a rotor or armature to provide a slight angular pattern helps to eliminate low speed cogging effects in an armature and minimize induced vibration in a rotor as well as reduce associate noise. Also, can help to increase starting torque.

Sleeve Bearings:
A type of bearings with no rolling elements, where the motor shaft rides on a film of oil.

Slip:
The difference between the speed of the rotating magnetic field (which is always synchronous) and the rotor in a non-synchronous induction motor is known as slip and is expressed as a percentage of a synchronous speed. Slip generally increases with an increase in torque.

Space Heater:
Small resistance heater units mounted in a motor, that are energized, during motor shutdown, to prevent condensation of moisture on the motor windings.

Special Purpose Motor:
Motor with special operating characteristics or speed mechanical construction, or both, designed for a particular application and not falling within the definition of a general purpose or definite purpose motor.

Splash-Proof Motor:
An open motor in which the ventilating openings are so constructed that drops of liquid or solid particles falling on it or coming toward it in a straight line at any angle not greater than 100 degrees from the vertical, cannot enter either directly or by striking and running along a surface of the motor.

Split Phase Start:
Motor which employs a main winding and an auxiliary winding, which is called the starting winding. The windings are unlike and thereby “split” the single phase of the power supply by causing a phase displacement between the currents of the two windings thus producing a rotating field. After the motor has attained approximately 75% of rated speed, the starting winding is automatically disconnected by means of a centrifugal switch or by a relay. The motor then continues to run on a single oscillating field, which in conjunction with the rotation of the rotor, results in a rotating field effect.

Since there is no rotating field, after the starting windings is de-energized, the rotation cannot be changed until the motor has come to rest or at least slowed down to the speed at which the automatic switch closes. Special starting switches are available as well as special reversing switches which have a means for shunting the open contacts of the automatic switch while the motor is running and thus permits the split phase motor to be reversed while rotating. This type of starting is found typically on single phase fractional motors.

Speed:
The speed of the motor refers to the rpm’s (revolutions per minute) of the shaft. For a three phase AC motor, the synchronous speed =

$$\frac{120 \times \text{frequency}}{\#\text{ of poles}}$$

frequency is measured in hertz

or cycles per second. The number of poles are a function of design.

Stabilized Shunt-Wound Motor:
A stabilized shunt-wound motor is a direct-current motor in which the shunt field circuit is connected either in parallel with armature circuit or to a separate source of excitation voltage and which also has a light series winding added to prevent a rise in speed or to obtain a slight reduction in speed with increase in load.

Starting Current:
Amount of current drawn at the instant a motor is energized- in most cases much higher than that required for running. Same as locked rotor current.

Starting Torque:
The torque or twisting force delivered by a motor at the instant it is energized. Starting torque is often higher than rated running or full load torque.

Stator:
That part of an a-c induction motor's magnetic structure which does not rotate. It usually contains the primary winding. The stator is made up of laminations with a large hole in the center in which the rotor can turn; there are slots in the stator in which the windings for the coils are inserted.

Stress Cones:
A physical protection placed over the external connections point on medium and high voltage motor leads. Stress cones are used to avoid di-electric breakdown of motor leads in the vicinity of the external connections. Stress cones generally require an oversized conduit box on large motors.

Suffixes to NEMA Frames:
Letter suffixes sometimes follow the NEMA frame size. Some of these suffixes, according to NEMA standards, have the following meanings:

Fractional Horsepower Motors

C. Face mounting
G. Gasoline pump motor
H. Indicates a frame having a larger "f" dimension
J. Jet pump motor
Y. Special mounting dimensions (see manufacturer)
Z. All mounting dimensions are standard except the shaft extension

Integral Horsepower Motors

A. DC motor or generator
C. Face mounting on drive end
D. Flange mounting on drive end
P. Vertical hollow and solid shaft motors with p-base flange.
HP. Vertical solid shaft motors with P-Base flange (normal thrust).
JM. Close-coupled pump motor with c-face mounting and special shaft extensions.
JP. Close-coupled pump motor with c-face mounting and special long shaft extension.
LP. Vertical solid shaft motors with p-base flange (medium thrust).
S. Standard short shaft for direct connection.
T. Standardized shaft - "T" frame.
X. Vertical mounting
Y. Special mounting dimensions
Z. All mounting dimensions standard except shaft extension.

Surge Protection:
A capacitor device usually mounted in the conduit box to flatten the voltage surges that may occur as a result of lighting or a power supply surge (short - period peak).
These surges could result in more than twice the rated voltage going to the windings and in turn cause winding damage.

Synchronous Motor:
A motor which operates at a constant speed up to full load. The rotor speed is equal to the speed. Of the rotating magnetic field of the stator; there is no slip. There are two (2) major types reluctance and permanent magnet on synchronous motors.; A synchronous motors is often used where the exact speed of a motor must be maintained.

Synchronous Speed:
The speed of the rotating magnetic field set up by the stator winding of an induction motor. In a synchronous motor the rotor locks into step with the rotating magnetic field, and the motor is said to run at synchronous speed. Approximately the speed of the motor with no load on it.

This is equal to $\frac{120 \times \text{Frequency}}{}$ = RPM (revolutions per minute)

"T" Frame:
Current NEMA designation identifying a-c induction motor frames. (NEMA has dimension tables which offer standard frame measurements) replaced the previous standard "U" frame in 1965.

Tachometer:
A small generator normally used a rotational speed sensing device. Tachometers are typically attached to the output shaft of DC or AC inverter motors accordingly (called "closed loop feedback" control).

Temperature:
Has direct bearing on the life expectancy, the following application considerations that affect the motor's operating temperature, should be taken into account:

1) Bearing
2) Lubricants
3) Duty Cycle
4) Radial Loading
5) Axial Loading
6) Mounting
7) Enclosure
8) Ambient Temperature
9) Ventilation

As a general rule of thumb each 10-degree Celsius increase in total temperature over the maximum permissible to the motor insulation system halves its life. Bearing or gear lubricant life is halved for every 25 degrees Celsius (approx. 14 degrees Celsius) increase in temperature. Heat eventually causes deterioration of most lubricants and seals leading to leakage and increased friction.

Temperature Rise:
Some of the electrical energy losses inherent in motors are converted to heat causing some of the motor parts to heat up when the motor is running. The heated parts are at a higher temperature than the air surrounding them thereby causing a rise above room (ambient) temperature. It is important to match the proper motor and insulation system (NEMA temp. Codes) to the appropriate ambient temperature. If a motor has been built with greater than 1.0 service factor then it can run at a temperature somewhat higher than the motor's rated operating temperature. In all cases, the actual insulation thermal capability usually is higher than the motor's operating temperature to allow for any excessive heat areas. This is called hot spot allowance. (see insulation systems for NEMA standard temperature codes.) each temperature code has an associated temperature rise which when added to the ambient and hot spot should not exceed the temperature handing of the insulation system.

Temperature Tests:
Tests conducted to determine the temperature rise of certain parts of a motor above the ambient temperature, when operating under specific conditions.

Test:

Routine

a routine test is a basic done in the factory the requirements of NEMA MG1, paragraph 12.51 and IEEE - 112-1978 and includes the following measurements: no load current/watts; winding resistance; and high potential test.

Complete

a complete test is a test which meets the requirements of IEEE - 112-1978. It includes the tests conducted in a routine test as well as: full- load heat run; no-load current and watts determination of torque's; efficiencies at 125, 100, 75, 50, and 25 percent of full load; power factor at 125, 100, 75, 50 and 25 percent of full load.

Witness

a witness test is a test performed with a customer representative present.

Noise

a test performed to verify the motor sound level, conducted in accordance with ieee-85. The tests are performed under no-load conditions in sound room.

Thermal Protector (Inherent):

An inherent overheating protective device which is responsive to motor temperature and which, when properly applied to a motor, protects the motor against dangerous overheating due to overload or failure to start. This protection is available with either manual or automatic reset.

Thermistor-Thermally Sensitive Resistor:

A semiconductor used to measure temperature; can be attached to an alarm or meter to detect motor overheating.

Thermocouple-Thermal Detection Device:

A temperature detecting device made of two dissimilar metals which generate a voltage as a function of temperature. Thermocouples can be attached to a meter or alarm to detect overheating of motor windings or bearings.

Thermostat:

Units applied directly to the motor's windings which senses winding temperature and may automatically break the circuit in an overheating situation.

Torque:

Turning force delivered by a motor or gearmotor usually expressed in

$$\text{lbs. ft} = \frac{\text{H.P.} \times 5250}{\text{RPM}} = \text{full load torque}$$

Totally Enclosed Enclosure:

A motor enclosure which prevents free exchange of air between the inside and the outside of the enclosure but is not air tight. Different methods of cooling can be used with this enclosure.

Totally Enclosed Air-To-Air Cooled Machine:

A totally enclosed machine cooled by circulating internal air through a heat exchanger which, in turn, is cooled by circulating external air. Provided with an air-to-air heat exchange for cooling ventilating air and fan or fans integral with rotor shaft or separate, for circulating external air.

Totally Enclosed Fan-Cooled Enclosure:

Provides for exterior cooling by means of a fan (s) integral with the machine, but external to the enclosed parts.

Totally Enclosed Non-Ventilated Enclosure:

Has no provisions for external cooling to the enclosed parts. The motor is cooled by heat radiation from the exterior surfaces to the surrounding atmosphere.

Totally-Enclosed Pipe Ventilated Machine:
A totally enclosed machine except for openings so arranged that inlet and outlet ducts or pipes may be connected to them for the admission and discharge of ventilating air. Air may be circulated by means integral with the machine or by means external to and not a part of the machine. In latter case, these machines shall be known as separately-forced-ventilated machines.

Totally-Enclosed Water Air-Cooled Machine:
A totally-enclosed machine cooled by circulating air which, in turn, is cooled by circulating water. Provided with water-cooled heat exchanger for cooling ventilating air and fan or fans, integral with rotor shaft or separate, for circulating ventilating air.

Transformer:
A device which converts electrical power (alternating current) to electrical power of a different voltage. In this device both primary and secondary windings are usually stationary, and are wound on a common magnetic core.

Thrust bearings:
Special bearings used to handle higher than normal axial forces exerted on the shaft of the motor as is the case with some fan or pump blade mountings.

Tube Cooled:
A motor in which heat is dissipated by air-to-air heat exchange.

"U" Frame:
A previously used NEMA designation indicating frame size and dimension (prior to 1965 the standard frame sizes per horsepower rating).

U.L. (Underwriter's Laboratory):
An independent testing organization which examines and tests devices, systems and materials with particular references to life, fire and casualty hazards. It develops standards for motor and control for hazardous locations through cooperation with manufactures. UL. has standards and tests for explosion-proof and dust ignition-proof motors which must be met and passed before application of the UL. label.

Vacuum Degassed Bearings:
Vacuum degassed is a process used in the purifying of steel for ball bearings assuring a very dense and consistent bearing surface. This results in a longer lasting superior bearing. All reliance electric ball bearings are vacuum degassed bearings.

Variable Torque:
A multi-speed motor used on loads whose torque requirements vary with speed as in some centrifugal pumps and blowers. The hp varies as the square of the speed.

Vertical Motor:
A motor being mounting vertically (shaft up or down) as in many pumps applications.

Vertical "P" Base Motor:
A vertical motor with a special mounting face conforming to nema's "p" design and with a ring groove on the shaft.

Voltage:
The force that causes a current to flow in an electrical circuit. Analogous to pressure in hydraulics, voltage is often referred to as electrical pressure. The voltage of a motor is usually determined by the supply to which it is being attached. NEMA requires that the motor be able to carry their rated horsepower at nameplate voltage plus or minus 10% although not necessarily at the rated temperature rise.

Voltage Drop:
Loss encountered across a circuit impedance from power source to applicable point (motor) caused by the resistance in conductor. Voltage drop across a resistor takes the form of heat released into the air at the point of resistance.

Watt:
The amount of power required to maintain a current of one ampere at a pressure of one volt. Most motors are rated in kilowatt equal to 1,000 watts. One horsepower is equal to 746 watts.

Weather-Protected Machine:
Type 1 (WPI) weather-protected machine is an open machine with its ventilating passages so constructed as to minimize the entrance of rain, snow and airborne particles to the electric parts and having its ventilating openings so constructed as to prevent the passage of a cylindrical rod 3/4 inch in diameter.

Weather-Protected Machine:
Type II (WPII) shall have, in addition to the enclosure defined for a type 1 weather-protected machine, it's ventilating passages at both intake and discharge so arranged that high velocity air and airborne particles blown into the machine by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electric parts of the machines shall be so arranged by baffling or separate housing as to provide at least three abrupt changes in direction, none of which shall be less than 90 degree. In addition, an area of low velocity not exceeding 600feet per minute shall be provided in the intake air path to minimize the possibility of moisture or dirt being carried into the electric parts of the machine.

Wound Rotor Induction Motor:
A wound rotor induction motor is an induction motor in which the secondary circuit consists of polyphase winding or coils whose terminals are either short- circuited or closed through suitable circuits. A wound rotor motor is sometimes used when high breakdown torque and a soft start or variable speed are required.

Wye-Delta Starting:
A method of starting a motor at rated voltage but drawing locked rotor current and producing reduced stocked rotor torque but it provides lower starting torque than a straight delta connection. Once the load and motor have been started the wiring will switch from the wye connection to a delta connection in which mode it must run and deliver full torque.