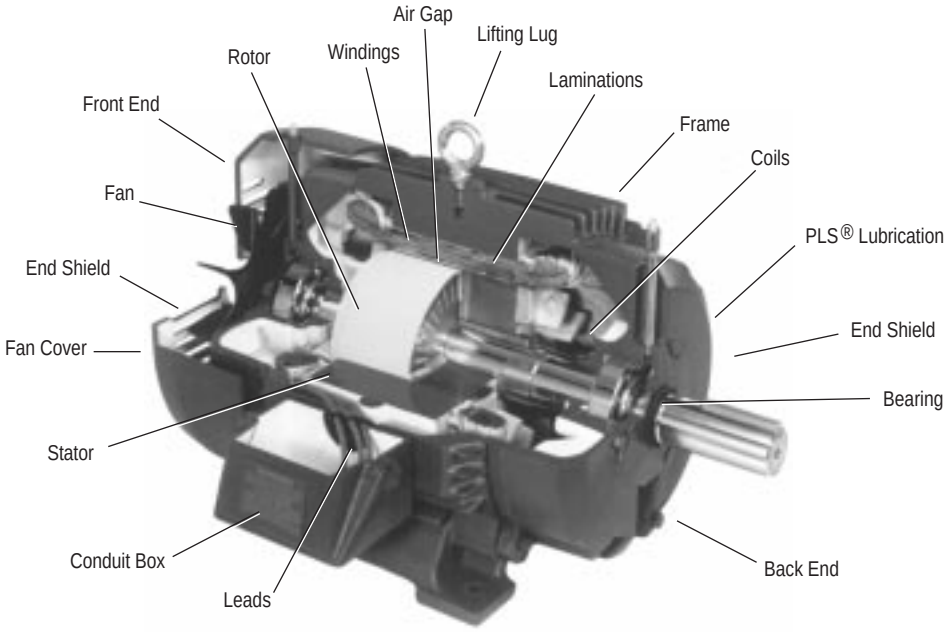
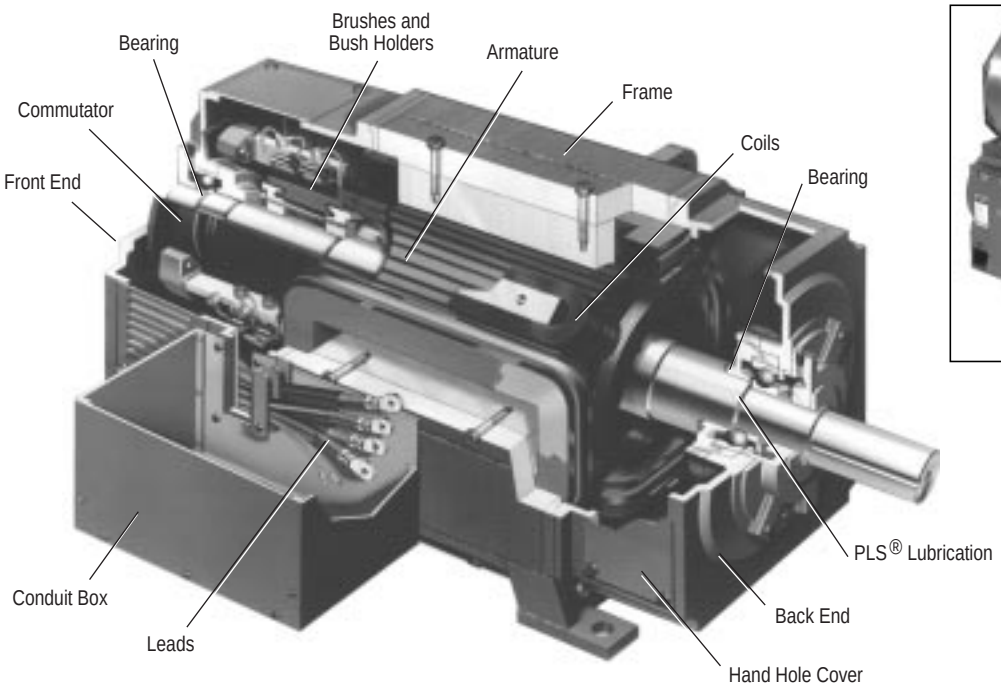
Glossary of Motor Terms

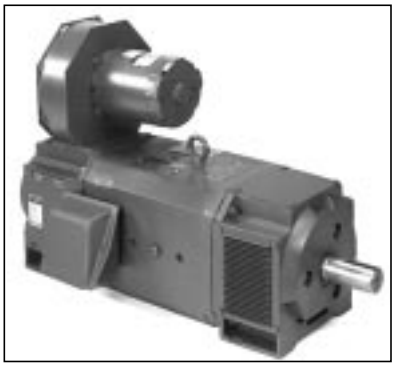
This motor terminology glossary is guide to explain and define a variety of terms and characteristics that apply to industrial AC and DC electric motors.

Typical AC Motor



Typical DC Motor





A

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 flow (cycles).

AC MOTOR
A motor *(see "MOTOR" on page 10)* operating on AC 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) members in an electric motor. *(See page 2.)*

AIR PRESSURE SWITCH
Used on motors with blowers to measure the difference in pressure across the filter to detect a clogged filter.

AIR TEMPERATURE SWITCH
A device used with an air hood motor to detect the temperature of the exhausted air. When used in this manner an air temperature switch will detect blockage in the cooling air system or long-term motor overload.

ALTITUDE
The atmospheric altitude (height above sea level) at which the motor will be operating; NEMA standards call for an altitude not exceeding 1,000 meters (3,300 feet). As the altitude increases above 1,000 meters (3,300 feet) and the air density decreases, the air's ability to cool the motor decreases. For higher altitudes, higher grades of insulation or motor derating are required. DC motors require special brushes for operation at 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 cooling medium is usually the air surrounding the motor. The standard NEMA rating for ambient temperature is not to exceed 40 degrees C.

ANTI-FRICTION BEARING
An anti-friction bearing is a bearing utilizing rolling elements between the stationary and rotating assemblies.

ARMATURE
The portion of the magnetic structure of a DC or universal motor which rotates. *(See page 2.)*

ARMATURE CURRENT, AMPS
Rated full load armature circuit current.

ARMATURE INDUCTANCE, MH
Armature inductance in milli-henries (saturated).

ARMATURE REACTION
The current that flows in the armature winding of a DC 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 effect the commutation and the magnitude of the motor's generated voltage.

ARMATURE RESISTANCE, OHMS
Armature resistance is measured in ohms at 25 degrees C (cold).

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

B

BACK END OF A MOTOR
The back end of a normal motor is the end that carries the coupling or driving pulley (NEMA). This is sometimes called the drive end (D.E.), pulley end (P.E.) etc. *(See page 2.)*

BASE SPEED, RPM
The speed in revolutions per minute (RPM) which a DC motor develops at rated armature and field voltage with rated load applied.

BEARINGS
Bearings reduce friction and wear while supporting rotating elements. When used in a motor, they must provide a relatively rigid support for the output shaft. *(See page 2.)*

Bearings act 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.

Ball bearings are used in virtually all types and sizes of electric motors. They exhibit low friction loss, are suited for high-speed operation and are compatible with a wide range of temperatures. There are various types of ball bearings such as open, single shielded and sealed. Allen-Bradley offers a unique PLS® bearing system. *(See "PLS®" on page 11.)*

BEARING LIFE
Rating life, L_{10} (B_{10}), is the life in hours or revolutions in which 90% of the bearings selected will obtain or exceed. Median life (average life), L_{50} (B_{50}), is the life in hours or revolutions in which 50% of the bearings selected will obtain or exceed.

BRAKES
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 as part of it.

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.

BREAK AWAY TORQUE
(See *"LOCKED ROTOR TORQUE" on page 10*.)

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 commutator of a commutated motor and conducts current from the power supply to the armature windings. *(See page 2.)*

C

CE
This designation shows that a product such as a motor or control meets European Standards for safety and environmental protection. A CE mark is required for products used in most European countries.

CIV (Corona Inception Voltage)
The minimum voltage amount that begins the process of ionization (corona) of motor windings.

CSA
Canadian Standards Association like U.L., sets specific standards for products used in Canada.

"C" FLANGE OR C-FACE
A type of flange used with close-coupled pumps, speed reducers and similar equipment 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 connected on the motor. The "C" type flange is a NEMA standard design and available with or without feet.

CANOPY (DRIP COVER)
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 (functions as an umbrella for the motor).

CAPACITOR
A device which, when connected 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 single-phase motors to start, or in three-phase motors for power factor correction.

CAPACITOR MOTOR
A single-phase induction motor with a main winding arranged for direct connection to the power source, and an 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, which has the same 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 better 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 since 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 predetermined 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. It is often used when many starts and stops are required.

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 coils, 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. *(See page 2.)*

COMMUTATOR
A cylindrical device mounted on the armature shaft and consisting of 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. *(See page 2.)*

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 variable speed is not required *(see "PARALLELING" on page 12.)* 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.

CONDUCTOR
A material such as copper 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.
(See page 2.)

CONSTANT HP (HORSEPOWER)
A designation for variable speed motors used for loads requiring the same amount of horsepower regardless of their motor speed during a normal operation.

CONSTANT TORQUE
Refers to loads with horsepower requirements that change linearly at different speeds. Horsepower varies with the speed, i.e., 2/1 HP at 1800/900 RPM (seen on some two-speed motors). Applications include conveyors, some crushers and constant-displacement pumps.

CONSTANT SPEED
A DC motor which changes speed only slightly from a no-load to a full-load condition. For AC motors, these are synchronous motors.

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

CORONA
This is the electrical discharge breakdown of a winding through the application of excessive voltage.

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.

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

CURRENT
This 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 US and 50 Hz is common in many foreign countries.

D

"D" FLANGE
A special end shield with untapped holes for through bolts in the flange. It is primarily used for mounting the motor to gear boxes or bulkheads. They are available in frame sizes 143T through 445T.

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" on page 10)*. A DC motor is often used when variable-speed operation is required.

DEFINITE PURPOSE MOTOR
A definite purpose motor is any motor design listed and offered in standard ratings with standard operating characteristics but with special mechanical features for use under service conditions other than usual or for use on a particular type of application (NEMA).

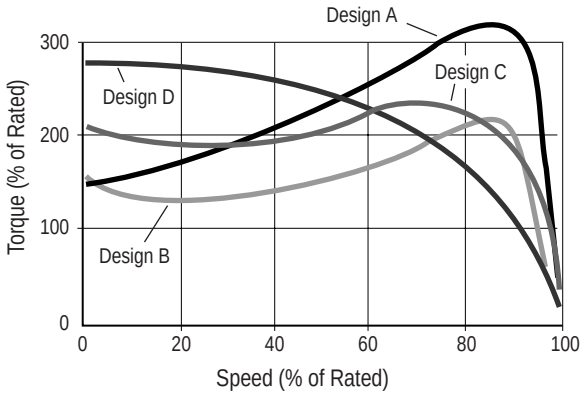
DUAL VOLTAGE
Some motors can operate on two different voltages, depending upon how it is built and connected. The voltages are either multiples of two or the √3 of one another.

DUTY CYCLE
The relationship between the operating and rest times or repeatable operation at different loads. A motor which can continue to operate within the temperature limits of its insulation system after it has reached normal operating (equilibrium) temperature is considered to have a continuous duty (CONT.) rating. A motor which never reaches equilibrium temperature but is permitted to cool down between operations, is operating under intermittent (INT) duty. Conditions such as a crane and hoist motor are often rated 15 or 30 minute intermittent duty.

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

DESIGN A, B, C, D – FOR AC MOTORS
NEMA has standard motor designs with various torque characteristics to meet specific requirements posed by different application loads. The design "B" is the most common design.

Design A, B, C, D for AC Motors



DIMENSIONS

NEMA has standard frame sizes and dimensions designating the height of the shaft, the distance between mounting bolt holes and various other measurements. 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.

Fractional horsepower motors, for which NEMA spells out dimensions, utilize 42, 48 and 56 frames. The shaft height in inches can be established by dividing the frame number by 16.

Design A, B, C, D - For AC Motors

Nema Design	Starting Torque	Starting Current	Breakdown Torque	Full Load Slip	Typical Applications
A	Normal	High	High	Low	Mach. Tools, Fans
B	Normal	Normal	Normal	Normal	Same as Design “A”
C	High	Normal	Low	Normal	Loaded compressor Loaded conveyor
D	Very High	Low	-	High	Punch Press

DRIP-PROOF GUARDED

A drip-proof machine with ventilating openings guarded (with screens) as in a guarded motor.

DRIP-PROOF MOTOR

An open motor in which the 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

A dual speed motor with torque values that vary with speed (as the speed changes the horsepower remains constant).

E

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 electrical input to mechanical output. 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 code on 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 equals 360 electrical degrees. One cycle in a rotating electrical machine is accomplished when the rotating field moves from one pole to the next pole of the same polarity. There are 360 electrical degrees 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

$$TC = \frac{L_a \times 1_a}{\text{Hot IR Voltage Drop}}$$

Where L_a is the armature circuit inductance in henries and 1_a is the rated full load armature current.

ELECTRICAL UNBALANCE

In a three-phase supply, where the voltages of the three different phases are not exactly the same. Measured as a percent of unbalance.

ELECTROMOTIVE FORCE (EMF)

A synonym for voltage, usually restricted to generated voltage.

ENCAPSULATED WINDING

A motor which has its winding 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.

ENCLOSURE

The housing or frame of the motor.

ODG..... Open Drip-Proof, Guarded
ODG-FV..... Open Drip-Proof, Force Ventilated
ODG-SV..... Open Drip-Proof, Separately Ventilated
ODP..... Open Drip-Proof
HP..... Vertical P-Base, Normal Thrust
LP..... Vertical P-Base, Medium Thrust, Extended Thrust
Prot...... Protected
TEAO..... Totally-Enclosed, Air-Over
TEBC..... Totally-Enclosed, Blower-Cooled
TECACA..... Totally-Enclosed, Closed Circuit, Air to Air
TEDC-A/A.... Totally-Enclosed, Dual Cooled, Air to Air
TEDC-Q/W... Totally-Enclosed, Dual Cooled, Air to Water
TEFC..... Totally-Enclosed, Fan-Cooled
TENV..... Totally-Enclosed, Non-Ventilated
TETC..... Totally-Enclosed, Tube Cooled
TEWAC..... Totally-Enclosed, Water/Air Cooled
TEXP..... Totally-Enclosed, Explosion-Proof
IP-22..... Open Drip-Proof (IEC Standard)
IP-44..... Totally-Enclosed (IEC Standard)
IP-54..... Splash Proof (IEC Standard)
IP-55..... Washdown (IEC Standard)
WPI..... Weather Protected, Type I
WPII..... Weather Protected, Type II
XE..... Premium Efficient
XL..... Extra Life
XP..... Explosion-Proof
XT..... Extra Tough

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.” *(See page 2.)*

EXPLOSION-PROOF ENCLOSURE

A totally enclosed enclosure, which is constructed to withstand an explosion of a specified gas, vapor or dust which, may occur within it. Should such an explosion occur, the enclosure would 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 – Locations in which ignitable concentrations of flammable or combustible material exist and come in contact with the motor.

DIVISION II – Locations 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-U.L. CLASSIFICATIONS

CLASS I

Those in which flammable gasses or vapors are or may be present in the air in quantities sufficient to product explosive or ignitable mixtures.

Group C Atmospheres containing ethyl or ether vapors.
Group D Atmospheres containing gasoline, hexane, benzine, butane, propane, alcohol, 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, coal 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. These cooling systems are used in certain duty cycle applications, with slow speed motors, or in environments with extreme dirt. Often a duct with an external blower is used to bring clean air into the motor’s air-intake.

F

FIELD

A term commonly used to describe the stationary (stator) member of a DC 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 DC motor to reduce the voltage and current which weakens the strength of the magnetic field and thereby increases the motor speed.

FLANGE

Mounting endshield 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. *(See “C” flange on page 4 and “D” flange on page 5.)*

FLUX

The magnetic field which is established around an energized conductor or permanent magnet. The field is represented by flux lines creating a 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) DC. A large departure from unity form factor (pure DC) 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 Irms/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 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 (FHP)
A motor usually built in a frame smaller than that having a continuous rating of one horsepower, open construction, at 1700-1800 rpm. Within NEMA frame sizes, FHP encompasses the 42, 48 and 56 frames. (In some cases the motor rating does exceed one horsepower, 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 frame size by 16.

FRAME
The supporting structure for the stator parts of an AC motor. In a DC motor, the frame usually forms a part of the magnetic coil. The frame also determines mounting dimensions *(see "FRAME SIZE" on page 8.)*

FRAME SIZE
Refers to a set of physical dimensions of motors as established by NEMA. These dimensions include critical mounting dimensions. NEMA 48 and 56 frame motors are considered fractional horsepower sizes even though they can exceed one horsepower. NEMA 143T to 449T is considered integral horsepower AC motors and 5000 series and above are called large motors. *(For definition of letters following frame number, see "SUFFIXES TO NEMA FRAMES" on page 15.)*

FREQUENCY
The rate at which alternating current makes a complete cycle of reversals. It is expressed in cycles per second. In the U.S., 60 cycles (Hz) is the standard while in other countries 50 Hz (cycles) is common. The frequency of the AC current will affect the speed of a motor *(see "SPEED" on page 15.)*

FRONT END OF A MOTOR
The front end of a normal motor is the end opposite the coupling or driving pulley (NEMA). This is sometimes called the opposite pulley end (O.P.E.) or commutator end (C.E.). *(See page 2.)*

FULL-LOAD CURRENT
The current flowing through the line when the motor is operating at 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.

G

GEARHEAD
The portion of a gearmotor, which contains the actual gearing which, converts the basic motor speed to the rated output speed.

GEARMOTOR
A gearhead and motor combination to reduce the speed of the motor to obtain the desired speed or torque.

GENERAL PURPOSE MOTOR
A general-purpose motor is any motor having a NEMA "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.

H

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 Hz which is 60 cycles per second).

HORSEPOWER (HP)
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 speed. For motors the following approximate formula may be used:

$$HP = \frac{T \times RPM}{5250}$$

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). This results in energy being expended and corresponding loss. Hysteresis loss in a magnetic circuit is the energy expended to magnetize and demagnetize the core.

I

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 voltages 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 be applied. This application may require a special motor due to the energy required to accelerate the inertia. Inertia is measured in either lb.-ft.^{2} or oz.-in.^{2}

$$\textit{Inertia reflected to the shaft of the motor} = \frac{(\textit{Load RPM})^2}{\textit{Motor RPM}}$$

INSULATOR

A material which tends to resist the flow of electric current (paper, glass, etc.). In a motor the insulation serves 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 constitute the motor's INSULATION SYSTEM. The following are typical in an AC motor:

1. TURN-TO-TURN INSULATION between separate wires in each coil. Usually enamel to 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 part 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 space. A total impregnation, applied in a fluid form and hardened, provides protection against contaminants.

INSULATION CLASS

Since there are various ambient temperature conditions a motor might encounter 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:.

Class	AC Motor w/1.00 S.F. Max. Total Temperature Range*	Class	DC Motor Total Temperature Range
A	105 degrees C	A	110 degrees C
B	130 degrees C	B	140 degrees C
C	155 degrees C	F	170 degrees C
D	180 degrees C	H	195 degrees C

* (Including Ambient and 110 degree C Hot Spot)

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 service that demands operation for alternate intervals of (1) load and no load; or (2) load and rest; (3) load, no load and rest; such alternative 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 frequency and fixed voltages to variable frequency and voltage. Enables the user to electrically adjust the speed of an AC motor.

I^2R

Losses due to current flowing in a conductor caused by resistance (equals the current squared times the resistance).

J

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.

$$J = \frac{WR^2 \times \text{Base RPM (seconds)}}{308 \times \text{Rated Torque}}$$

JACKSCREW

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

K

KILOWATT (kw)

Since the watt is a relatively small unit power, the kilowatt – (kw) 1,000 watts – is used where larger units of power measurement are desirable.

L

LAMINATIONS

The steel portion of the rotor and stator cores make up 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. *(See page 2.)*

LARGE MOTORS

Usually refers to AC motors with 5000 series frames and above or DC motors with 500 series frames and larger.

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 lubrication is required (application of an oil or grease). The bearings are the major motor component requiring lubrication (as per manufacturer’s instructions). Excess lubrication can however damage the windings and internal switches, etc. *(see “PLS®” on page 11).*

M

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 one pole in a clockwise direction, it must proceed 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 multispeed motor is a two-speed although three- and four-speeds are sometimes available. Multi-speed motors can be wound with two sets of windings or one winding. They are also available with constant torque, variable torque or constant horsepower.

Skin temperature identification numbers

Max. Surface Temperature *Degrees C (F)*	T-Codes ID Number	UL Req. for Class & Group
450 (842)	T1	N/A
300 (572)	T2	N/A
280 (536)	T2A	Class I Group D w/cautionary label
260 (500)	T2B	N/A
230 (446)	T2C	N/A
215 (419)	T2D	Class I Group D

Max. Surface Temperature *Degrees C (F)*	T-Codes ID Number	UL Req. for Class & Group
200 (392)	T3	Class II Group E & F
180 (356)	T3A	Class I Group C w/cautionary label
165 (329)	T3B	Class II Group G
160 (320)	T3C	Class I Group G
160 (320)	T3C	Class I Group C
135 (275)	T4	N/A
120 (248)	T4A	N/A
100 (212)	T5	N/A
85 (185)	T6	N/A

N

NAMEPLATE
The plate on the outside of the motor describing the motor horsepower, voltage, speed 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.

N.E.C. TEMPERATURE CODE ("T" CODE)
A National Electrical Code index for describing maximum allowable "skin" (surface) temperature of a motor under any normal or abnormal operating conditions. The "T" codes are applicable to U.L. listed explosion-proof motors. The skin temperature shall not exceed the minimum ignition temperature of the substances to be found in the hazardous location. The "T" code designations apply to motors and other types of electrical equipment subject to hazardous location classification.

NEMA
The National Electrical Manufacturers Association is a non-profit organization organized and supported by manufacturers of electric equipment and supplies. NEMA has set standards for:

- Horsepower ratings
- Speeds
- Frame sizes and dimensions
- Standard voltages 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.

O

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 oil to the bearing in the event that the oil mist is interrupted and is fed from a source outside the bearing housing such as a constant level oiler.

OPEN BEARING
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
A machine which is ventilated with external air by means of a separate motor-driven blower mounted on machine enclosure.

OPEN PIPE-VENTILATED MACHINE
An open machine except that openings for admission of ventilating air are 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 not a part of the machine. In the latter case, this machine is sometimes known as a separately- or force-ventilated machine.

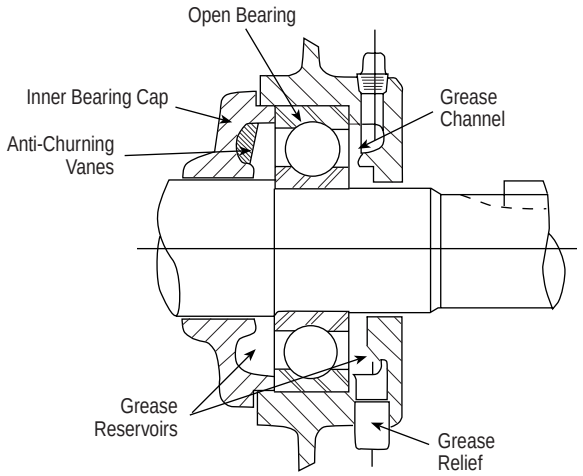
OPEN (PROTECTED) MOTOR
A motor having ventilating openings which permit passage of external cooling air over and around the windings. The term "open machine," when applied to large apparatus without qualification, designates a machine having no restriction to ventilation other than that necessitated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

P

"P" BASE
A special mounting similar to "D" flange except with a machined fit tenon recessed instead of protruding. Usually found on pumps.

PLS®
An exclusive bearing and lubricating system which permits complete lubrication of the bearing whether the motor is mounted vertically or horizontally. This system also helps prevent over lubrication, which would shorten motor life. An additional benefit to PLS lubrication is cooler running bearings.

PLS Construction



PARALLELING

When two or more DC 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 to 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 then carry 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.

PHASE

Indicates the space relationships of windings and changing values of the recurring cycles of AC voltages 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 in position. Each voltage 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- or three-phase (with 120 electrical degrees between the three-phases).

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 caution.

POLARIZATION TEST

A ratio of one-minute meggar test to ten-minute meggar test *(see "MEGGAR TEST" on page 10)*. Used to detect contaminants in winding insulation done typically on high voltage V.P.I. motors, which are tested by water immersion.

POLES

In an AC motor, refers to the number of magnetic poles in the stator winding. The number of poles determines the motor's speed. *(see "SYNCHRONOUS SPEED" on page 15.)*

In a DC motor, refers to the number of magnetic poles in the motor. They create 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 for 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 (three-phase) power supply is available and is limited primarily to industrial applications.

Starting and reversing torque characteristics of polyphase 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 DC motor. Frequency, voltage, and type of rectifier configuration.

POWER FACTOR

A measurement of the time phase difference between the voltage and current in an AC 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 (volt amperes).

PRIMARY WINDING

The winding of a motor, transformer or other electrical device which is connected to the power source.

PROTECTIVE RELAY

The principal function of a relay 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 AC motor during the period of acceleration from zero to the speed at which 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 achieving rated speed.

R

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

$$R = \frac{\text{Hot IR Voltage Drop}}{\text{Terminal Volts} - (\text{Hot IR Voltage Drop})}$$

Where: Hot IR Voltage Drop =
(Rated 1a x Hot Armature Circuit Resistance) + 2.0 (Brush Drop) Volts.

RPM (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
A resistance device used to measure temperature change in the motor windings to detect a possible over heating condition. These detectors are embedded into the winding slot and their resistance varies with temperature.

Bearing RTD
A 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.

REFLECTIVE WAVE
Reflective waves can occur in variable-speed motor applications when the drive and motor are placed a considerable distance apart. The combination of long lead (cable) lengths and the fast switching semiconductors in the drive can cause voltage spikes at the motor's terminals. These spikes can cause the motor's insulation to deteriorate.

RELAY
A device that is operative by a variation in the conditions of one electric circuit to effect 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. Reluctance motors have lower efficiencies, power factors and torques 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 measure to 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 horsepower motors for fans and blowers.

REVERSING
Unless otherwise specified, a general-purpose DC motor is reversible. A DC 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 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 contactors. An AC motor is reversed by reversing the 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. *(See page 2.)*

S

SCREENS
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 MOTORS
Where high starting torques are required for a DC 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 (SF)
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 SF can produce 15% greater torque than the 1.0 SF 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 of their slots with respect to the shaft axis. This pattern helps to eliminate low speed cogging effects in an armature and minimize induced vibration in a rotor as well as reduce associated noise. It can also help to increase starting torque.

SLEEVE BEARINGS
A type of bearing 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. It is expressed as a percentage of 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 in the motor windings.

SPECIAL PURPOSE MOTOR
Motor with special operating characteristics or special 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
Motors, which employ a main winding and an auxiliary winding, 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 winding is deenergized, 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 contracts 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 RPMs (revolutions per minute) of the shaft. For a three-phase AC motor . . .

$$\text{Synchronous Speed} = \frac{120 \times \text{Frequency (frequency measured in Hertz)}}{\text{\# of Poles}}$$

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 the 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.

STANDARDS ORGANIZATIONS

ABS..... American Bureau of Shipping
ANSI..... American National Standards Institute
API ..... American Petroleum Institute
BASEEFA..... British Approval Service for Electrical
..... Equipment in Flammable Atmospheres
BISSC ..... Baking Industry Standards Committee
CE ..... Compliance to European Standards
CSA..... Canadian Standards Association
EPACT ..... 1997 U.S. Energy Policy Act
IEC ..... International Electrotechnical Commission
IEEE..... Institute of Electrical and Electronics Engineers
ISO..... International Standards Organization
MIL ..... Military Specifications
MSHA..... U.S. Mining, Safety, Health Administration
NAFTA..... North American Free Trade Agreement
NEC ..... National Electric Code
NEMA..... National Electrical Manufacturers Association
UL ..... Underwriter's Laboratories
UR..... Underwriter's Laboratories Recognized
USDA ..... U.S. Department of Agriculture
USCG..... U.S. Coast Guard

STARTING CURRENT

Amount of current drawn at the instant a motor is energized--in most cases much higher than the 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 AC 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. *(See page 2.)*

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 connection. Stress cones generally require an oversized conduit box on large motors.

SUFFIXES TO NEMA FRAMES

Letter suffixes sometimes follow the NEMA frame size designations. 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
V ..... 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 can 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 major synchronous motor types: reluctance and permanent magnet. A synchronous motor 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 . . .

$$\text{RPM} = \frac{120 \times \text{Frequency (frequency measured in Hertz)}}{\text{\# of Poles}}$$

T

"T" FRAME

Current NEMA designation identifying AC 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 as a rotational speed sensing device. Tachometers are typically attached to the output shaft of DC or AC variable-speed motors requiring close speed regulation. The tachometer feeds its signal to a control which adjusts its output to the DC or AC motor accordingly (called “closed loop feedback” control).

TEMPERATURE
Has direct effect on motor life when considering life expectancy. The following application considerations that affect a motor’s operating temperature should be taken into account:

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

As a general rule, each 10°C increase in total temperature over the maximum permissible to the motor’s insulation system, reduces its life by half. Bearing or gear lubricant life is reduced by half for every 25°F (approximately 14°C) increase in temperature. Heat eventually causes deterioration of most lubricants and seals leading to leakage and increased friction.

“T” (TEMPERATURE CODES)
(See *“N.E.C. TEMPERATURE CODE (“T” CODE)” on page 11*.)

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 which causes a rise above room (ambient) temperature.

It is important to match the proper motor and insulation system (NEMA temp. codes) to the expected ambient temperature. If a motor has been built with greater than 1.0 service factor, then it can operate 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 handling 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.

TESTS
ROUTINE

A routine test is a basic test done in the factory to the requirements of NEMA MG1, paragraph 12.51 and IEEE-112-1978. It 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 a full-load heat run; no-load current and watts determination of torques; 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 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 that 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 generates 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 shaft, usually expressed in . . .

$$lb.\text{-}ft. = \frac{HP \times 5250}{RPM} = \text{Full Load Torque}$$

TOTALLY-ENCLOSED ENCLOSURE
A motor enclosure, which prevents free exchange of air between the inside and the outside of the enclosure but is not airtight. 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 exchanger 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 of 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 arranged so 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 motors 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

"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 reference to life, fire and casualty hazards. It develops standards for motors and controls used in hazardous locations through cooperation with manufacturers. U.L. has standards and tests for explosion-proof and dust ignition-proof motors, which must be met and passed before application of the U.L. label.

V

VACUUM DEGASSED BEARINGS
Vacuum degassing is a process used in the purifying of steel for ball bearings ensuring a very dense and consistent bearing surface. This results in a longer lasting superior bearing. All ball bearings are vacuum degassed bearings.

VARIABLE TORQUE
A multi-speed motor used on loads with torque requirements, which vary with speed as with some centrifugal pumps and blowers. The horsepower varies as the square of the speed.

VERTICAL MOTOR
A motor being mounted vertically (shaft up or down) as in many pump applications.

VERTICAL "P" BASE MOTOR
A vertical motor with a special mounting face conforming to NEMA design "P" 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 attached. NEMA requires that motor be able to carry its 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.

W

Wk_2 (MOMENT OF INERTIA)

The moment of inertia is expressed as Wk^2 in terms of pound-feet squared. It is the product, the weight of the object in pounds and the square of the radius of gyration in feet.

If the application is such that the motor is driving through a pulley or gear so that the driven equipment is operating at a higher or lower speed than the rotor, it is necessary to calculate the inertia reflected to the motor shaft. This is an equivalent Wk^2 (reflected to motor shaft) = Wk^2 based on the speed (rpm) of the motor.

$$Wk_2 \text{ (reflected to motor shaft)} = \frac{Wk_2 \text{ (driven equipment) x (driven equipment rpm)}}{(\text{motor rpm})_2}$$

WATT

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

WEATHER-PROTECTED MACHINE

TYPE I (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. Its ventilating openings are constructed to prevent the passage of a cylindrical rod 3/4 inch in diameter.

WEATHER-PROTECTED MACHINE

TYPE II (WPII) have, in addition to the enclosure defined for a Type I weather-protected machine, its 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 machine itself. The normal path of the ventilating air which enters the electric parts of the machines are arranged by baffling or through a separate housing to provide at least three abrupt changes in direction, none of which shall be less than 90 degrees C. In addition, an area of low velocity not exceeding 182.9 meters (600 feet) per minute.

Notes

PLS is a registered trademark of Rockwell Automation

Online Documentation

The latest motor information can be obtained from the Allen-Bradley Drives & Motors home page on the World Wide Web at:

http://www.ab.com/drives/motors

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Publication Motors-9.0 – February, 1999
Supersedes July, 1998