AC Motor Basics

Basic Motor Terminology

Air Gap - opening between stator and rotor

Altitude - operational/installation altitude

Ambient – temperature of the space around the motor

Base – adapter base used to convert "T" frame motors to "U" frame; slide base is an adjustable frame on which the motor sets (belt apps)

Bearing Housing – end bell or bracket which houses the motor bearing and supports rotor

Breather Drain – plug type device use to provide drainage

Conduit Box – also terminal box, contains motor leads or terminals connected to power source

Design – letter assigned by NEMA to denote standard performance characteristics

For internal use only.

Basic Motor Terminology

Drip Cover – umbrella type cover used to keep water out of motor (vertical mounting)

Duty Cycle – continuous duty, suitable for 24 hour day operation

Enclosure – motor housing

Flange – also called “Face”, a specially machined drive end bearing housing used to provide easy mounting to driven equipment

Insulation System – maximum allowed operating temperature of the motor

Laminations – slotted stampings or punchings of thin electrical grade steel, stacked and joined together

Rotor – rotating element of the motor

Stator – stationary part of the motor that contains the windings

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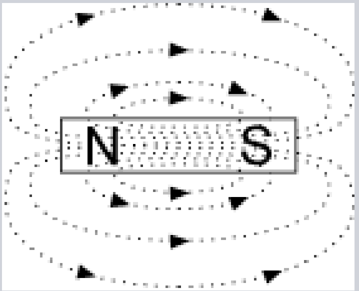
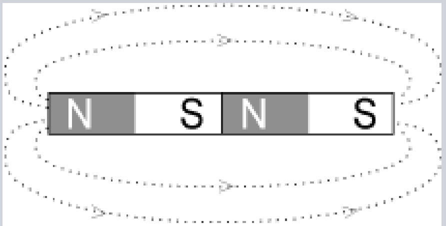
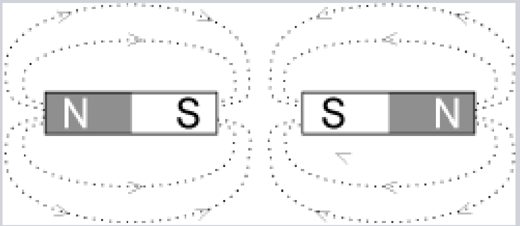
Magnetism

Magnetic Line of Flux

- A magnet's invisible force
- North Pole/South Pole
- Unlike Poles Attract/ Like Poles Repel







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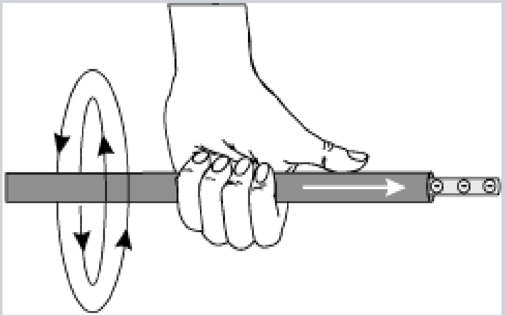
Electromagnetism

Electromagnetic field is generated by current flow in a conductor

- Left-hand rule for conductors
- Magnetic strength varies proportionally with current flow



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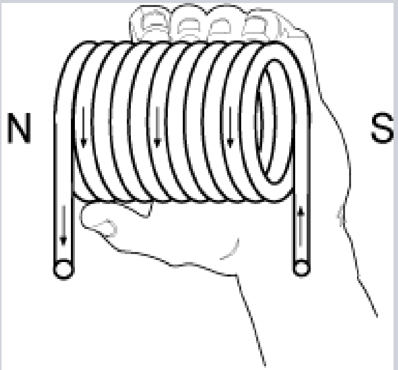
Electromagnetism

Electromagnet is made by winding a conductor into a coil around a core

- Core is usually a soft iron
- Current passing through coil magnetizes core
- Left-hand rule for coils
- Magnetic strength varies proportionally with the number of turns



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Motor Specifications

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NEMA Premium

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NEMA PREMIUM© EFFICIENCY

CONNECTION

1 2 3

LINE

TYPE: SD100

HP: 50

kW: 37.30

FRAME: 326 T TEFC

VOLTS: 460

AMPS: 58.0

R.P.M: 1780 Hz: 60

NEMA NOM EFF: 94.5 %

SH. END BRG: 60BC03JP3

OPP. END BRG: 60BC03JP3

VFD COMPATIBLE AT 1.0 S.F.

20:1 V.T., 4:1 C.T.

DUTY: CONT. 3 PH

CLASS INSUL: F S.F.: 1.15

S.F. AMPS: 67.0

AMB.TEMP.: 40 °C

TEMP.RISE: CLASS B

NEMA DESIGN: B

kVA CODE: G

PART No: PRUEBAAL

SERIAL No:

CC032A LR 39020

Made in Mexico by SIEMENS GDL

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Motor Specifications

Horsepower

- Horsepower (US) = (T x rpm) / 5250
- kilowatts (Europe) = .746 x HP
- Fractional: 1/3, ¼, ½, ¾
- Integral: 1-20,000 + Hp

Voltage

- Electromotive (emf) force required to make electricity flow through a conductor
- 115, 200, 230, 460, 575, 2300, 4000, 4600, 6600, 7200V and 13.2 kV

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Motor Specifications

Frequency

- Like a magnet the magnetic field of an electromagnet has a north and south pole
- When direction of current flow changes, polarity of electromagnet changes
- The process repeats itself 60 or 50 times a second

Altitude

- Motors suitable for 3300 ft ASL or 1000 m
- Class F Insulation suitable for 9900 ft ASL

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Motor Specifications

Pole = (120)Hz/Ns

No. of Poles	Synchronous Speed
2	3600/3000
4	1800/1500
6	1200/1000
8	900/750
10	720/600

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Motor Specifications

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Slip

- Relative difference between speed of rotor and rotating magnetic field
- Necessary to produce torque

$$\% \text{ Slip} = \frac{Ns - Nr}{Ns} \times 100$$

$$\% \text{ Slip} = \frac{1800 - 1765}{1800} \times 100$$

$$\% \text{ Slip} = 1.9\%$$

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Motor Specifications

Service Factor

- A multiplier applied to the rated power
- 1.0, 1.15 or 1.25

Motor Design

- NEMA Design A, B, C, D
- Standard for motor performance

Efficiency

- Indicates how much input AC energy is converted to output mechanical energy

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Motor Specifications

Insulation Class	Class F	Class H
Slot Liner/Wedges and Coil Separator	100% fill polyester fiber-polyester film-polyester fiber laminate	Nomex laminate-polyester film-Nomex laminate
Sleeves	Acrylic coated glass impregnated with varnish	Flexible silicone rubber trated fiberglass
Tie Cord	Heat shrinkable polyester	Heat shrinkable polyester
Varnish	100% solids polyester resin	100% solids polyester resin
Leads	Cross linked polymer or Teflon	Silicone Rubber or Teflon

Maximum Winding Temperature Rise °C

1.0 SF				1.15 SF		
A	B	F	H	A	B	F
60	80	105	125	70	90	115

40 deg C ambient, Resistance Method

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NEMA Motor Characteristics

NEMA Design A - not often used (high LRA)

NEMA Design B - most common

NEMA Design C - high torque

NEMA Design D - high torque and high slip

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NEMA Motor Characteristics

NEMA Design B

- Most common
- The relationship between speed and torque from moment of start until motor reaches full-load torque at rated speed is expressed in a Speed-torque curve

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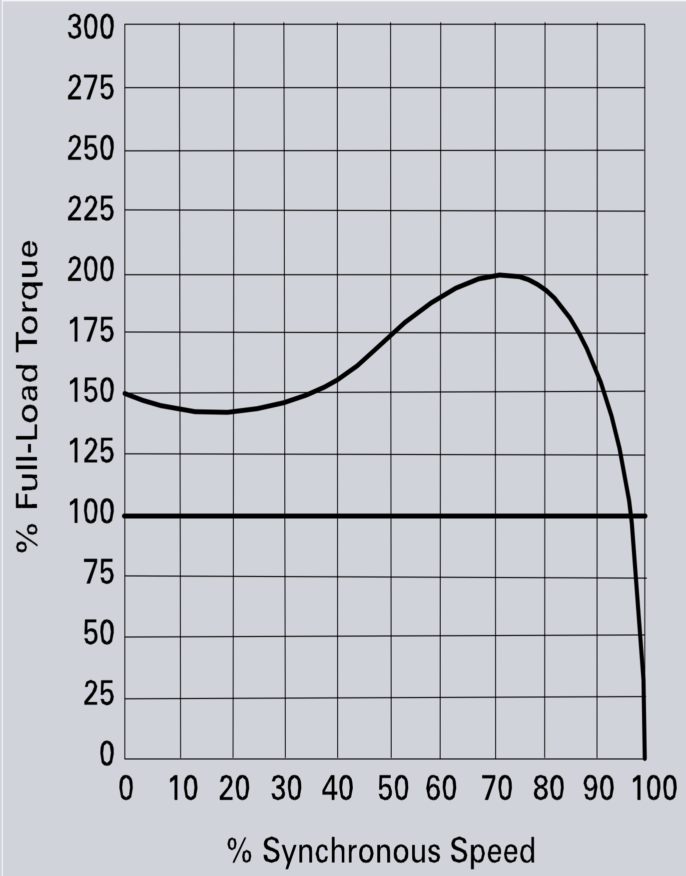
Speed-torque Curve

Starting (Locked Rotor) Torque

Accelerating Torque

Breakdown Torque

Full Load Torque



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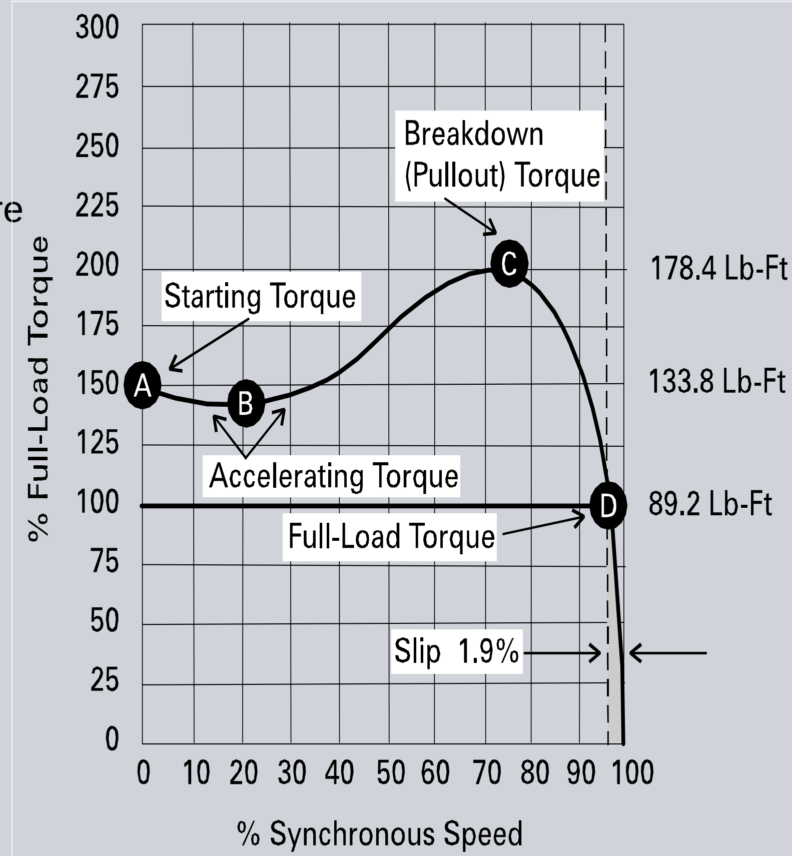
Motor Torque

(A) ***Locked Rotor Torque*** – Minimum torque developed by motor at rest, with rated voltage applied at rated frequency

(B) ***Accelerating Torque*** – The torque developed by the motor during acceleration from rest to the speed where breakdown torque occurs

(C) ***Breakdown Torque*** – Maximum torque developed by motor with rated voltage applied at rated frequency

(D) ***Full Load Torque*** – The torque necessary to produce its rated horsepower at full-load speed



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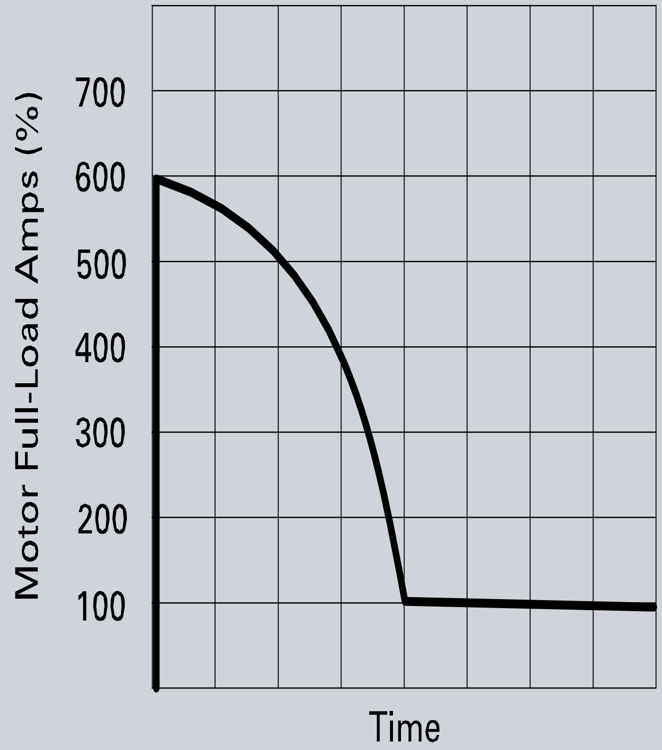
Current

Locked-Rotor Current: starting current measured from supply line at rated voltage and frequency with the rotor at rest (600-650% for NEMA B)

Full-Load Current: current measured from supply line at rated voltage, frequency and load with the rotor up to speed



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NEMA Motor Characteristics

NEMA Design A

- Higher LRA will yield NEMA Design A
- Used for special load torque or inertia requirements

NEMA Design C

- Starting torque approximately 225%
- High inertia load applications (conveyors, plunger pumps)
- Single speed motors from 5-200 HP

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NEMA Motor Characteristics

NEMA Design D

- Starting torque approximately 280%
- Very high inertia load applications (punch presses, cranes, hoists)
- No true breakdown torque
- After initial LRT is reached, torque decreases until FLT is reached
- High slip (5-8% or 8-13%)

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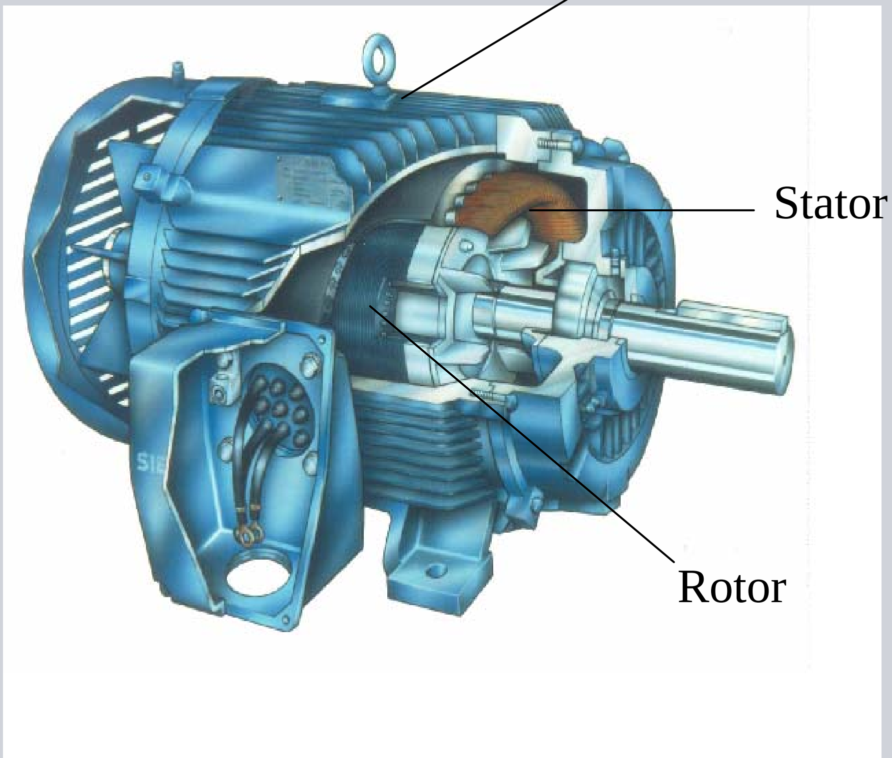
Motor Construction

Three basic parts

- Rotor
- Stator
- Enclosure



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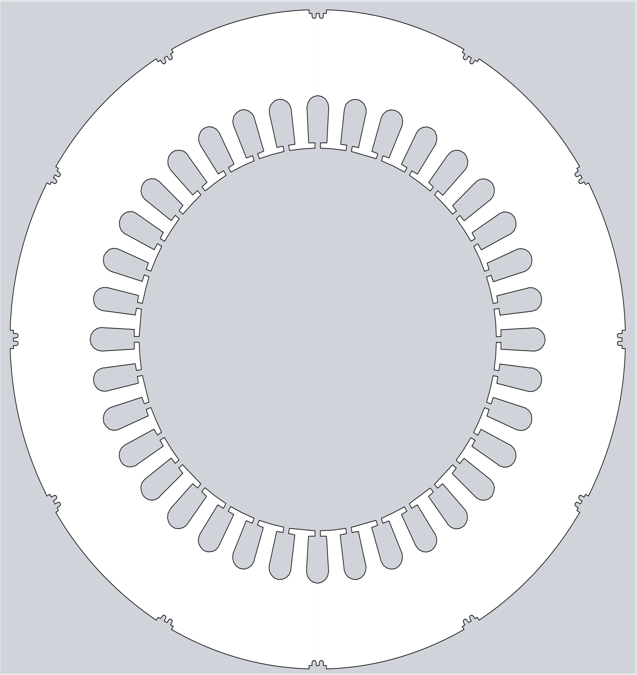
Stator Construction

- Stator and Rotor are electrical circuits that perform as Electrical magnets
- Stator is the stationary electrical part of the motor
- Made up of several
- hundred thin laminations



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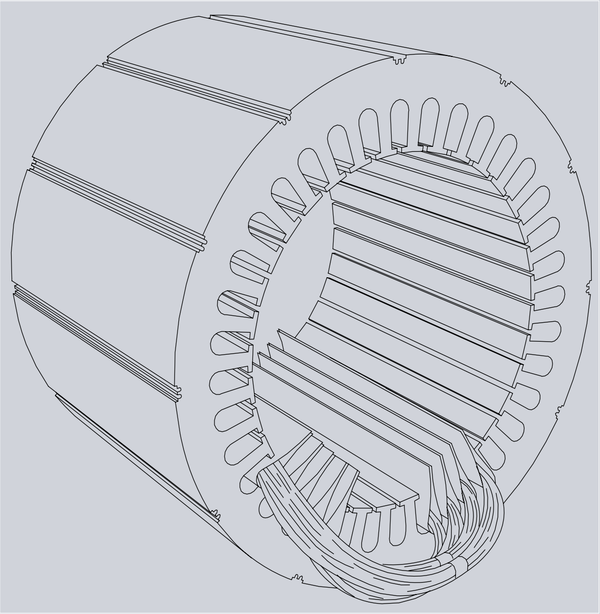
Stator Construction

Stator laminations stacked together forming a hollow cylinder

Coils of insulated wire inserted into stator core slots



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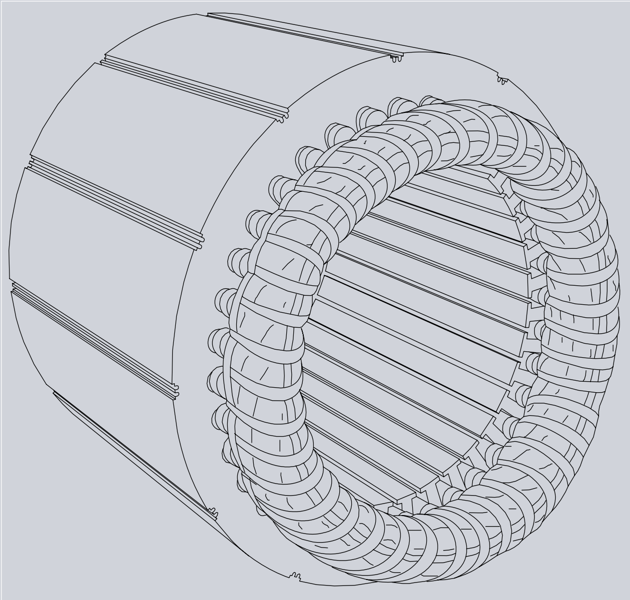
Stator Construction

Each grouping of coils, together with the steel core it surrounds form an electromagnet

Stator windings connected to power source



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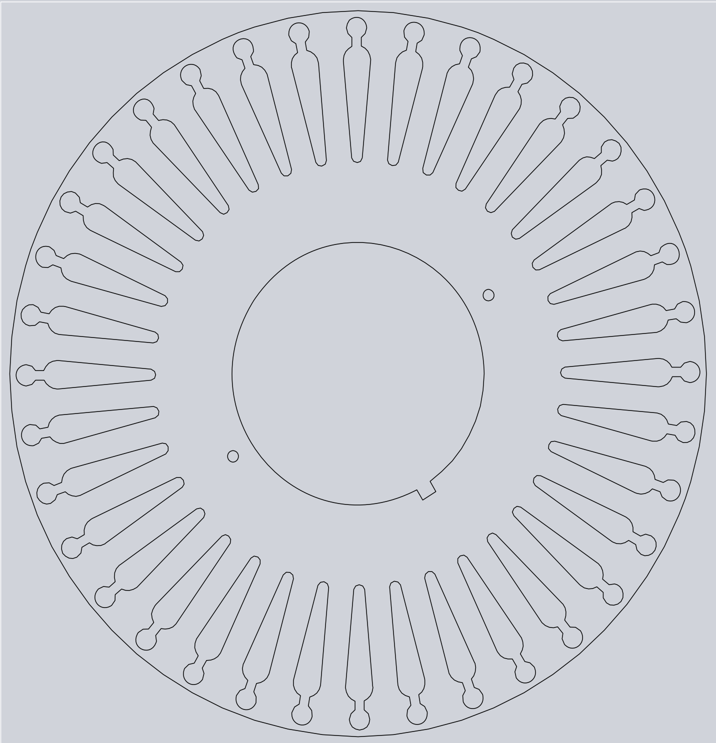
Rotor Construction

The rotor is the rotating part of the electromagnet circuit



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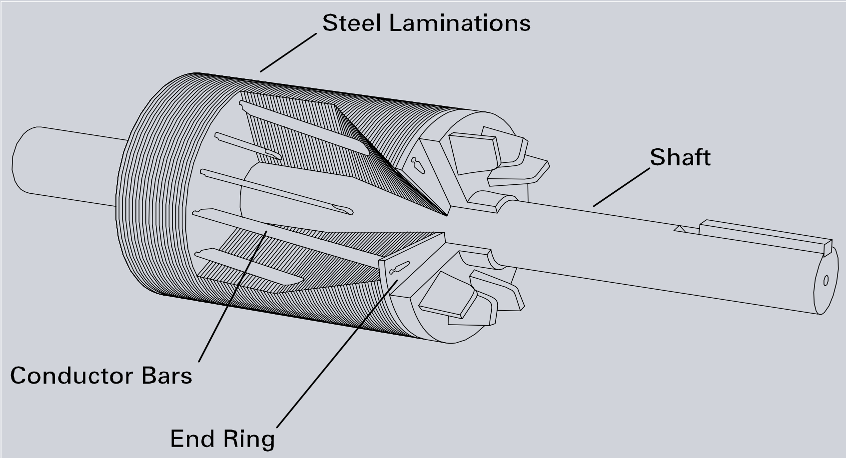
Rotor Construction

Laminations stacked together with evenly spaced conductor bars

Aluminum or copper die cast in the slots form a series of conductors around perimeter

Current flowing through conductors form electromagnet



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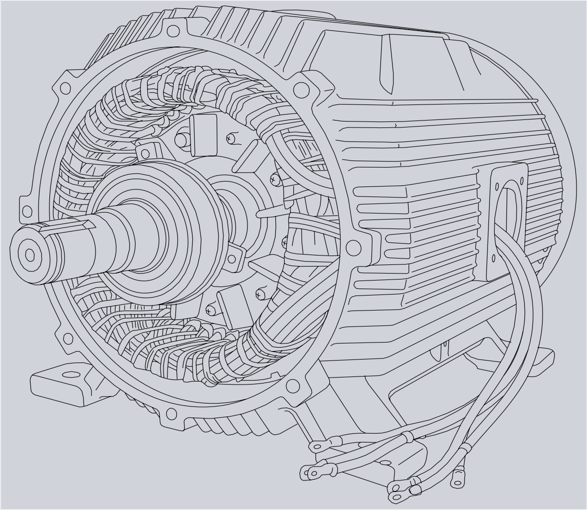
Enclosures

Consists of Frame (Yoke) and two end brackets (bearing housings)

Stator is mounted inside frame

Rotor fits inside stator

- Slight air gap
- No physical contact between stator and rotor



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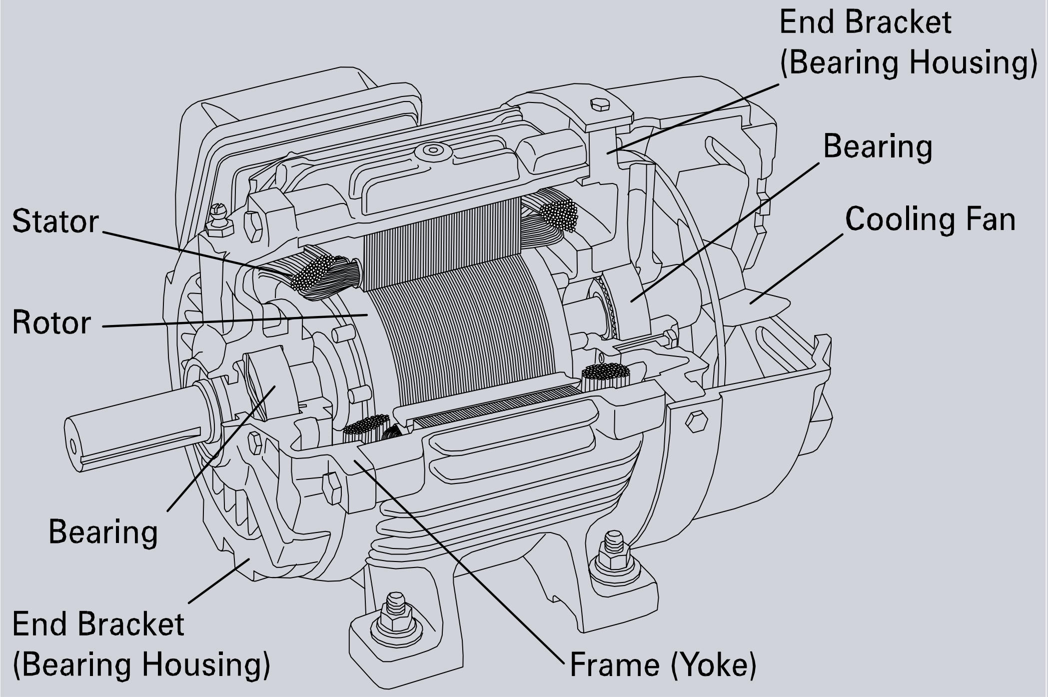
Enclosures

Protects electrical and operating parts of motor from harmful environmental effects



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Enclosures

ODP: Open Drip Proof

TEFC: Totally Enclosed Fan Cooled

TENV: Totally Enclosed Non-ventilated

TEAO: Totally Enclosed Air-over

WP1/WP2: Weather Protected 1 and 2

TEAAC: Totally Enclosed Air-to-Air Cooled

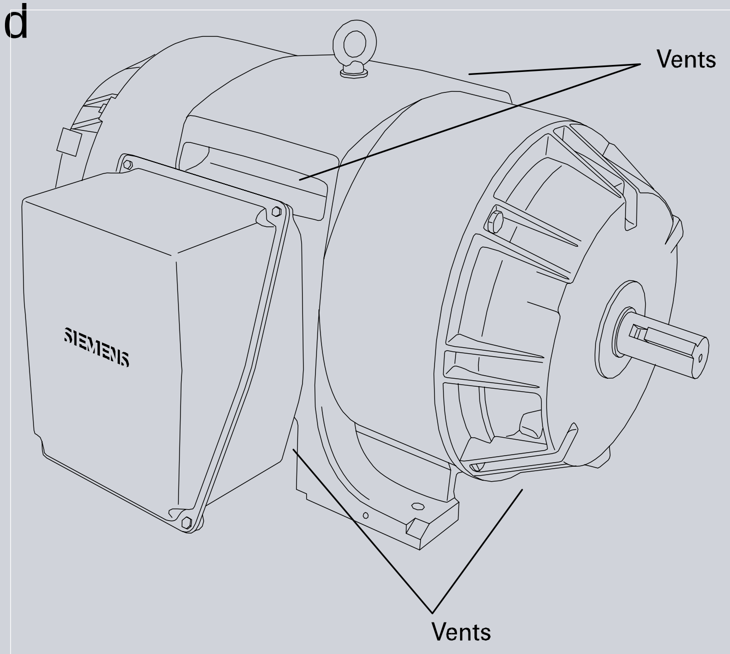
TEWAC: Totally Enclosed Water-to-Air Cooled

For internal use only.

Open Drip Proof (ODP)

Permit cooling air to flow through motor

Vent opening prevent liquids and solids from entering at from above angles up to 15º



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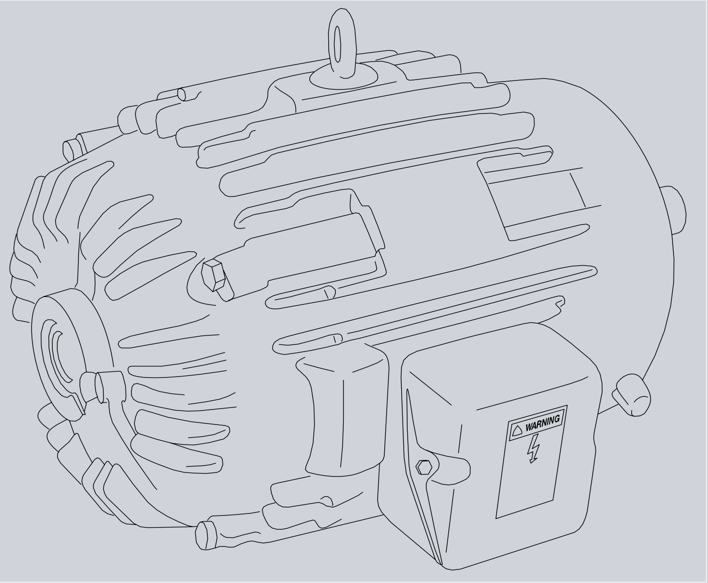
Totally Enclosed Non-ventilated

TENV restricts free exchange of air between inside and outside of motor

All heat dissipates by means of conduction

Indoors and outdoors

Most TENV motors are fractional



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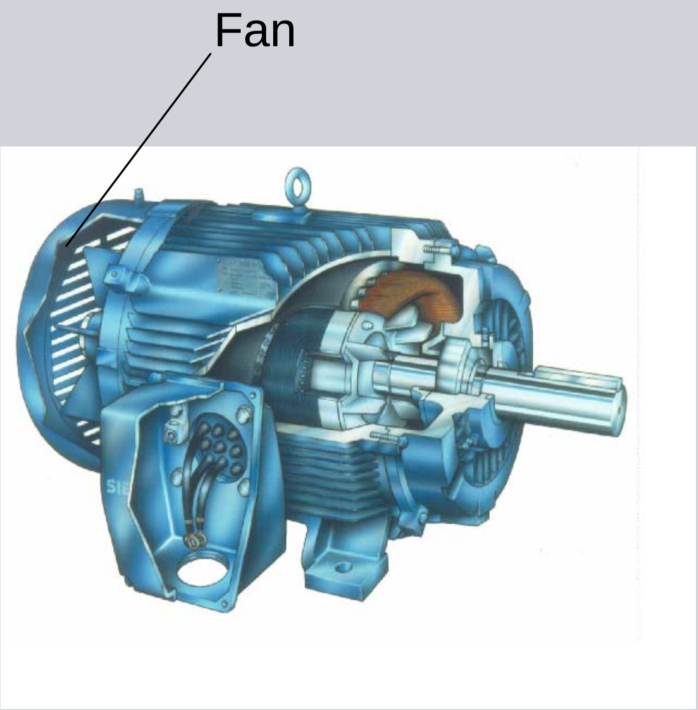
Totally Enclosed Fan Cooled

TEFC is similar to TENV with addition of a fan

Can be used in dirty, moist, or mildly corrosive conditions

More widely used for integral HP

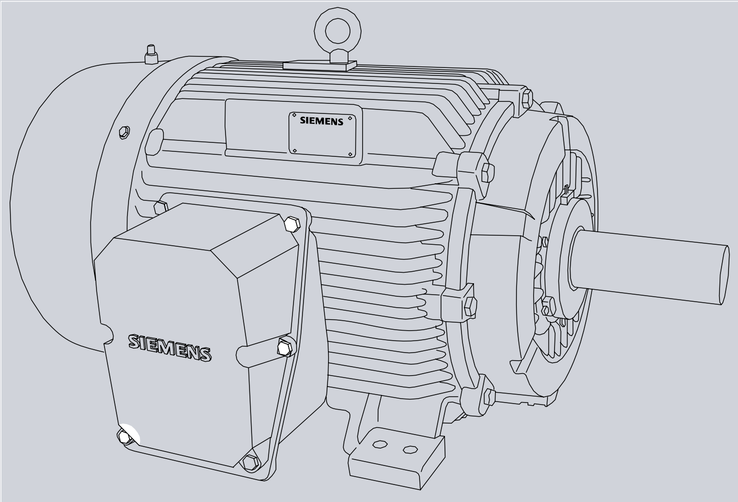


Explosion Proof (XP)

Similar in appearance to TEFC

Most are Cast Iron

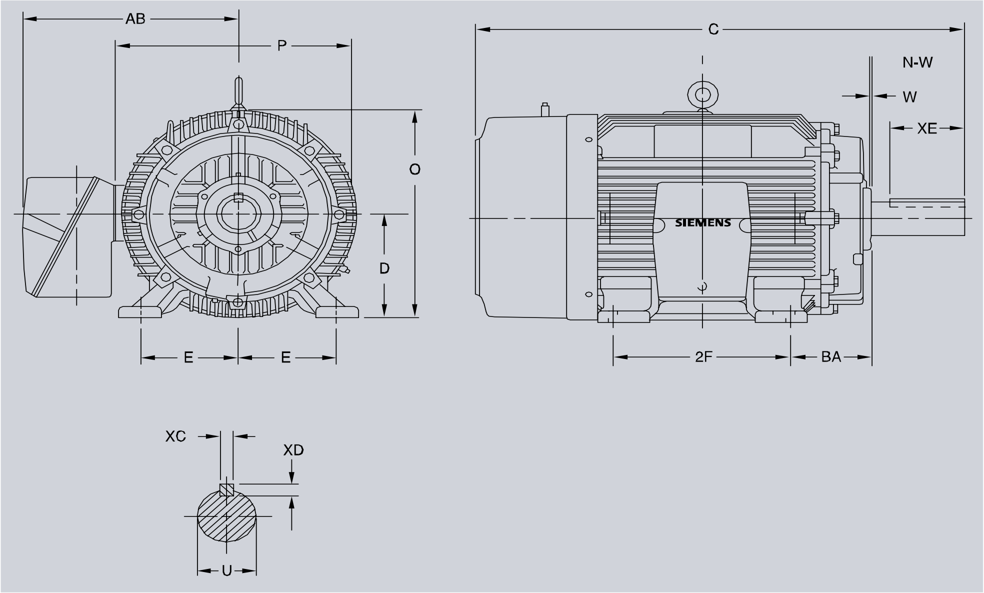
Application subject to agencies such as NEC and UL



Mounting

NEMA Dimensions- 143T

- 14/4 = 3.5 (shaft height)
- 3 = distance between bolt holes



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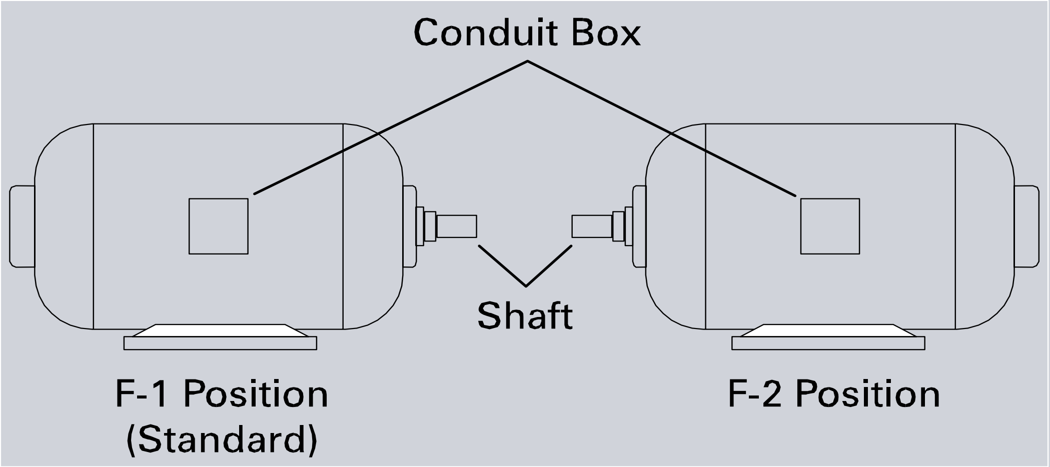
Mounting Positions

F-1

- Standard
- Conduit box on left-hand side of motor when viewed from shaft end

F-2

- Conduit box on right-hand side of motor when viewed from shaft end



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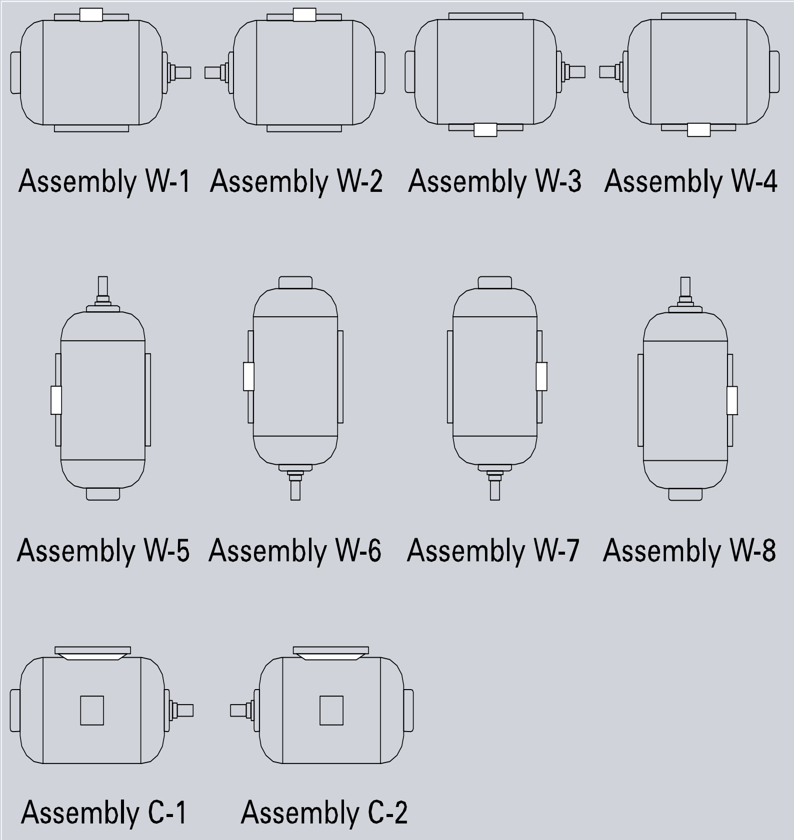
Mounting Positions



Wall mounted

- "W" Prefix

Ceiling mounted

- "C" Prefix

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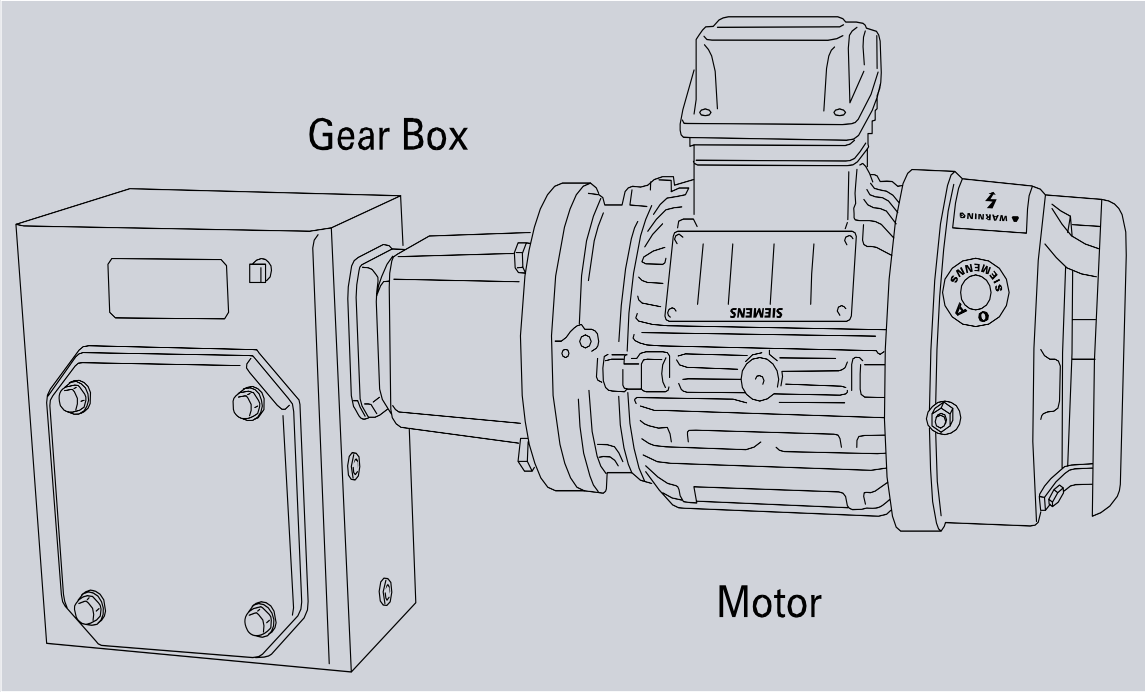
Flanges or Faces

For mounting directly to equipment



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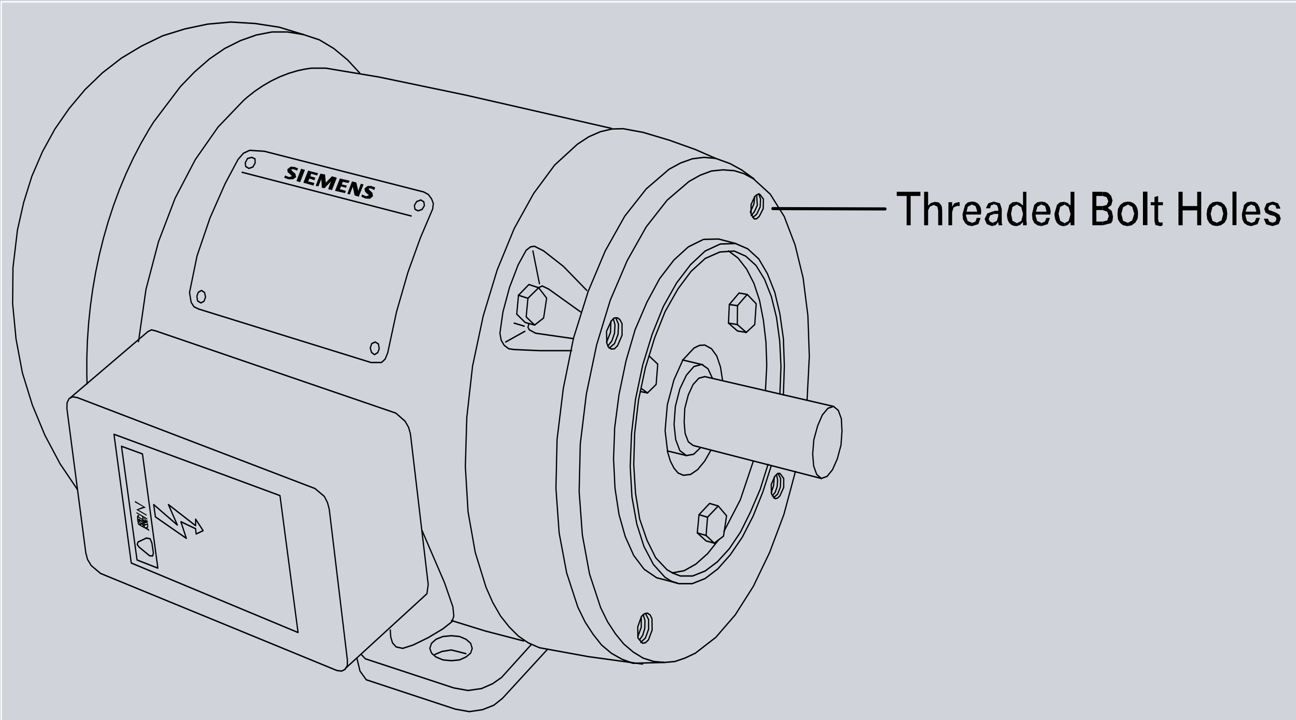
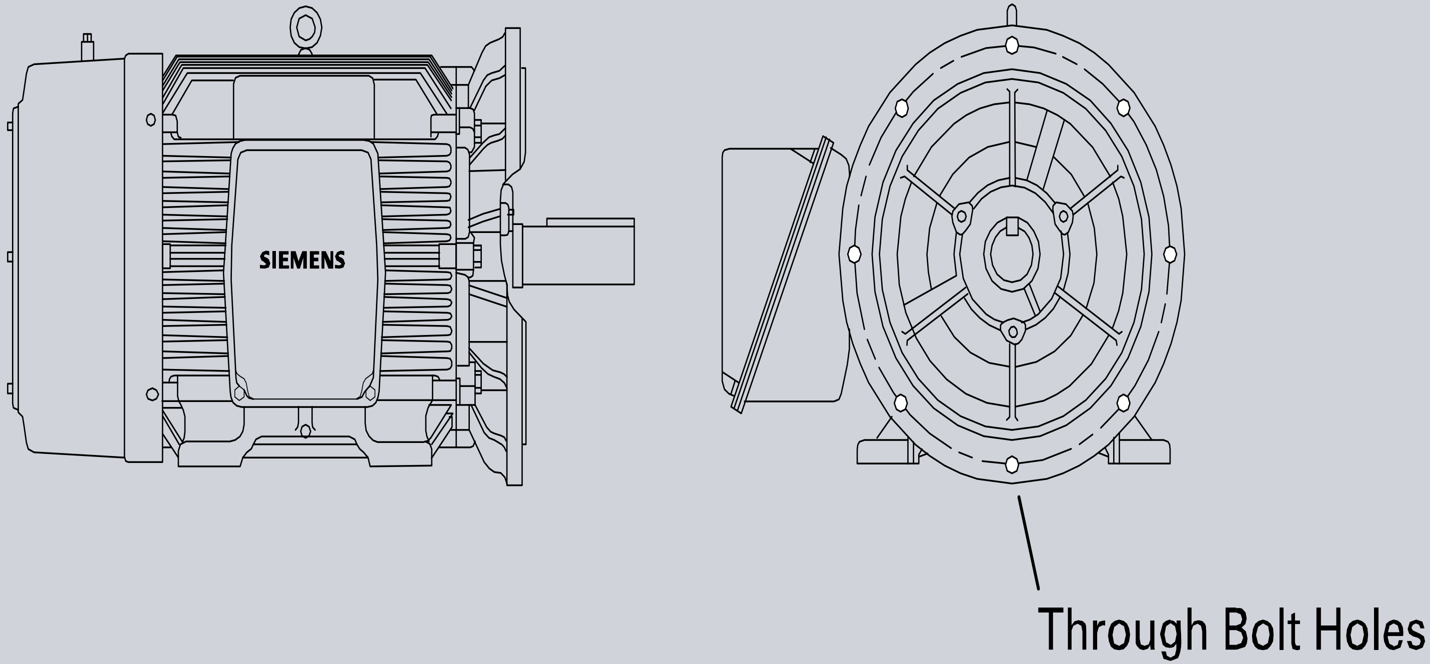
C-Face

Threaded Bolt Holes



D-Flange

Through Bolt Holes



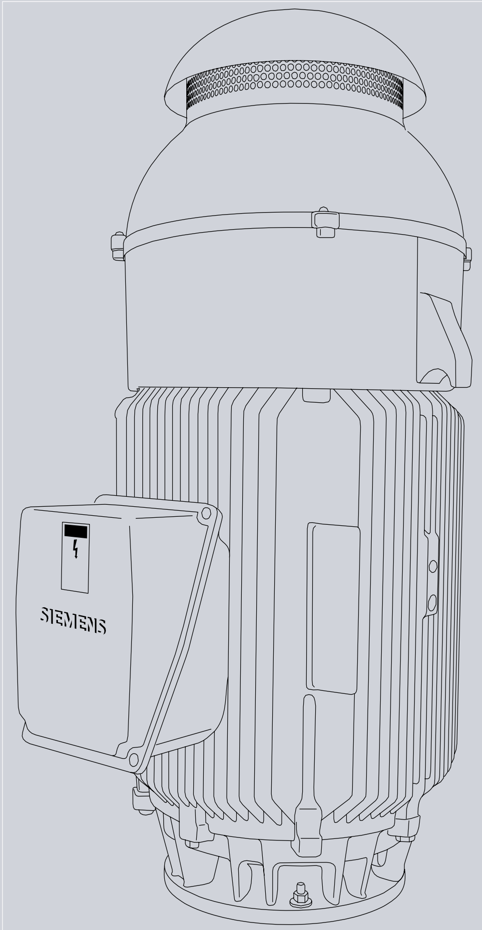
Vertical Pump Motors

P Flange, Hollow Shaft

- No longer offered by Siemens
- 25 to 250 HP at 1800 RPM
- 460 VAC

P Flange, Solid Shaft

- 3 to 100 HP at 3600 RPM, 3 to 250 HP at 1200 and 1800 RPM



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Siemens Product Lines – New NEMA

Totally Enclosed Fan Cooled

- GP100A, GP100
- SD10MS, SD100, SD100 IEEE
- RGZVESD, RGZVILESD

Explosion Proof Motors

- XP100
- XP100ID1

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Siemens Product Lines – ODP and Legacy Motors

Open Drip Proof (no longer available)

- DP10
- RGE1, RGE, RG

Totally Enclosed Fan Cooled

- RGZP, RGZESD,RGZEESD, RGZEESDX (841)

Totally Enclosed Fan Cooled, Explosion Proof

- RGZZESD

Definite Purpose Motors

- RGZVESD, RGZVILESD, RGZESDI

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Siemens New NEMA Motor Nomenclature

GP = General Purpose

A = Aluminum Frame

IEEE = IEEE 841

10 = EPACT Efficiency

NP = NEMA Premium (meets)

SD = Severe Duty

XP = Explosion Proof

Brake = Brake Duty Motor

100 = NEMA Premium Efficiency

NPP = NEMA Premium Plus (exceeds)

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Siemens New NEMA Motor Nomenclature

Type	Description
GP10 (OBSOLETE)	TEFC, EPACT
GP10A (OBSOLETE)	TEFC, EPACT, AL frame
GP10A Brake (OBSOLETE)	TEFC, EPACT, AL frame, Brake duty
GP100	TEFC, NP
GP100A	TEFC, NP, AL frame
SD10 (OBSOLETE)	TEFC, SD, EPACT
SD100	TEFC, SD, NP
SD100 IEEE	TEFC, SD, NP, IEEE 841
XP100	TEFC, XP, SD, NP
XP100 ID1	TEFC, XP, SD, NP, Group D

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Siemens Legacy Motor Nomenclature

RG = ODP

E = Premium Efficiency

EE = NEMA Premium Efficiency

SD = Severe Duty

ZZ = Explosion Proof (XP)

I = Inverter Duty

F = C-flange, foot mounted

CT = Cooling Tower

RGZ = TEFC

P = EPACT Efficiency

X = IEEE 841

AD = Automotive Duty

T = NEMA Design C

IL = In-Line Pump “P”

V = C-flange, Round Body

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Siemens Legacy Motor Nomenclature

Type	Description
RG	ODP
RGE	ODP, PE
RGZ	TEFC
RGZP	TEFC, EPACT Efficiency
RGZE	TEFC, PE
RGZSD	TEFC, SD
RGZESD	TEFC, PE, SD
RGZPSD	TEFC, EPACT Eff., SD
RGZESDX	TEFC, PE, SD, IEEE 841
RGZZSD	TEFC, XP, EPACT Eff., SD
RGZZESD	TEFC, XP, PE, SD
RGZAD	TEFC, AD
RGZEAD	TEFC, AD, PE
RGZCT	TEFC, CT
RGZECT	TEFC, PE, CT
RGZTESD	TEFC, PE, SD, NEMA “C”
RGZESDI	TEFC, PE, SD, Inverter Duty
RGKESDI	TENV/TEFC, PE, SD, Inverter Duty

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Questions