AC MOTORS

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- CODE LETTERS AND ENCLOSURE DEFINITIONS
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- FRAME ASSIGNMENTS AND DIMENSIONS
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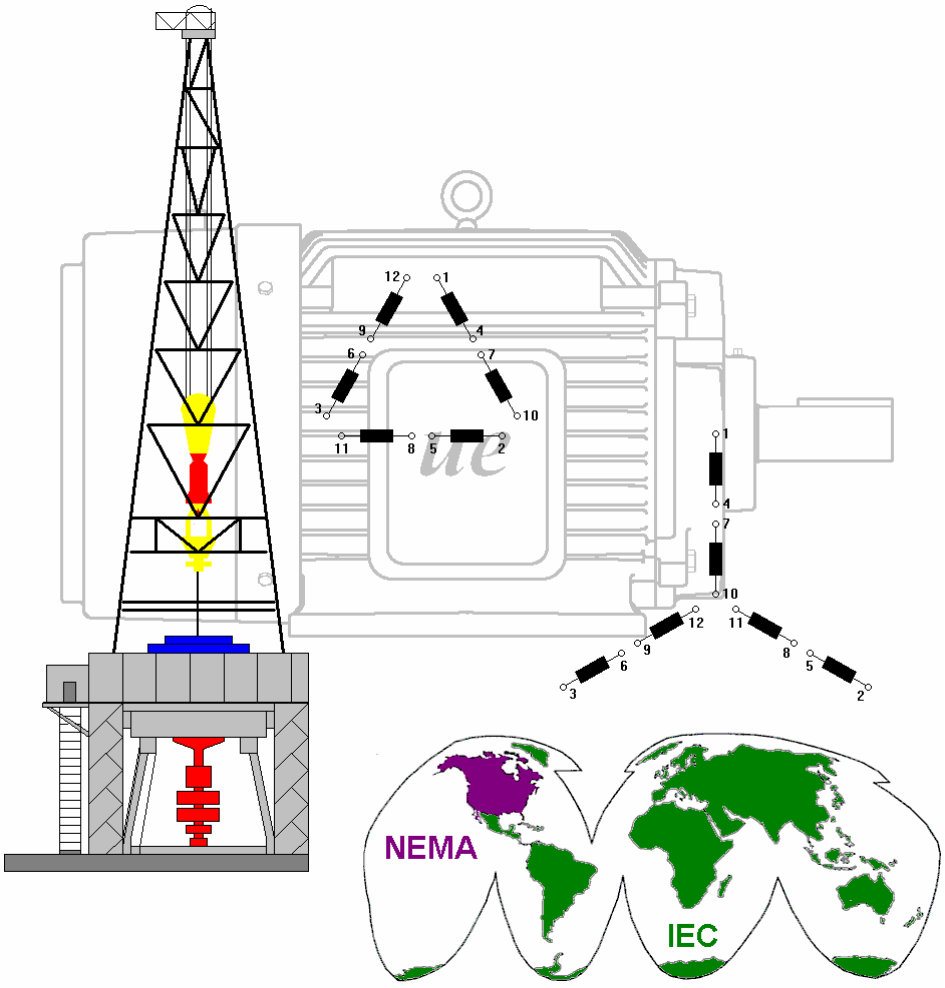
- MOTOR STARTERS
- ……



CONTENS:

BASIC MOTOR TERMINOLOGY

AND NAMEPLATE DESIGNATION

- **AFBMA**
  Anti-Friction Bearing Manufacturers Association – an organization of most bearing manufacturers that establishes standards for bearings.

- **Air Gap**
  Opening between the stator and rotor.

- **Air Over**
  Motors for fan or blower service and cooled by the air stream from the driven fan or blower.

- **Amperes, Amps (A)** …current flow in an electrical circuit
  Amount of current consumed by the motor.

- **Ambient**
  The temperature of the space around the motor.
  Most motors are designed to operate in an ambient not over 40 °C (104 °F)

- **Bearing Housing (End Bell)**
  Houses the bearing of motor and supports the rotor.

- **Breakdown Torque (BDT)**
  The maximum value of torque that a motor will develop without a sudden decrease in speed.

- **Breather**
  Plug type device to provide drainage of condensation or water from motor.

- **Canadian Standards Association (CSA)**
  Sets safety standards for motors and other electrical equipment used in Canada.

- **Catalog**
  Mod. (Model), Tp. (Type), or Cat. (Catalogue), this is the number that you need if you want to contact the manufacturer for ordering parts, etc.

- **CCW**
  Counter-Clockwise Rotation, when facing the motor from the shaft end, this is the direction of rotation of the motor.

- **CFM**
  Cubic Feet per Minute. Standard air flow quantification used to describe air flow across coils and through ducted fan systems.

- **Cooling**
  Normal ambient temperatures should not exceed 40°C, if standard performance is to be achieved. Check that the motor has sufficient airflow. Ensure that no nearby equipment radiate additional heat to the motor.

- **CW**
  Clockwise Rotation, when facing the motor from the shaft end, this is the direction of rotation of the motor.

- **Cycles or Hertz (Hz)**
  Frequency, in cycles per second, of AC power; usually 60Hz in USA and 50 Hz overseas.

- **Delta (Delta Winding)**
  Many motors have two different ways of connecting the windings to three phase power. For further information's pls. refer to the chapter "TERMINAL MARKINGS AND CONNECTIONS".

- **Design (Design Letter)**
  Is assigned by NEMA to denote standard performance characteristics relating to torque, starting current and slip.

- **Efficiency**
  A measurement of how effectively a motor turns electrical energy into mechanical energy.

- **Enclosure (Enc.)**
  The term used to describe the motor housing or the degree of protection offered by the enclosure.

- **End Bell (Bearing Housing)**
  Houses the bearing of motor and supports the rotor.

- **Flange (Face)**
  Machined drive end bearing housing with flat surface and bolt holes to provide easy mounting to driven equipment. Used extensively on pumps and gear reducers, NEMA flanges are designated by C, D or P and the letter will appear on the nameplate in the frame space, i.e. 256TC, etc.

- **Frame or frame size (Fr)**
  Refers to NEMA standardized motor mountings and shaft dimensions. This is important when it is necessary to locate a mechanical replacement for an old motor.

- **Full load amperes (F.L.A.)**
  Line current (amperage) drawn by a motor when opening at rated load and voltage on motor nameplate. Important for correct wire size, and motor starter heater selection.

- **Hertz (Hz) or Cycles**
  Frequency, in cycles per second, of AC power; usually 60Hz in USA and 50 Hz overseas.

- **Horsepower:**
  Output power rating of the motor. American made motors or older British or Canadian motors, will probably be rated in Horsepower. European and Asian motors are usually rated in kilowatts.
  1 HP = 3/4 kW (0.746 kW).

- **IEC**
  The IEC is the International Electro technical Commission. Although the IEC includes Japan and the United States of America among its members, the IEC is essentially a European Community standards association. IEC standards are heavily influenced by VDE - the German electrical standards association.

- **Inrush Current or Locked Rotor Amps (L.R.A.)**
  Line current drawn by a motor at starting or when nameplate voltage is applied and the rotor is not rotating (locked).

- **Insulation**
  In motors, classified by maximum allowable operating temperature:
  Class A = 105 °C, Class B = 130 °C, Class F = 155 °C, Class H = 180 °C.
  The motor rise plus the ambient temperature should be equal to or less than the maximum allowable temperature for the insulation class.

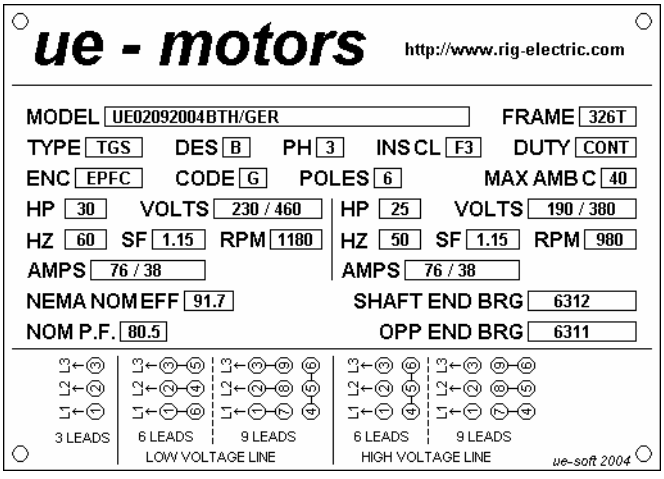
- **Locked Rotor Amps (L.R.A.) or Inrush Current**
  Line current drawn by a motor at starting or when nameplate voltage is applied and the rotor is not rotating (locked).
- **Locked Rotor Time or Stall Time**
  Time in seconds that a motor can withstand locked rotor (stalled) current without damage.

- **Locked Rotor Torque (L.R.T.) - (Starting Torque or Breakaway Torque)**
  The torque developed by the motor when starting or when stalled (rotor blocked).

- **Manufacturer**
  This is the trade name of the company which manufactured the motor.

- **Model**
  Mod. (Model), Tp. (Type), or Cat. (Catalogue), this is the number that you need if you want to contact the manufacturer for ordering parts, etc.

- **Nameplate**



The nameplate is provided by the manufacturer to allow users to identify the operating and dimensional characteristics of the motor. It is usually a metal plate, located on the side of the motor.

- **National Electrical Code**
  A code for safeguarding persons and property from the hazards arising from the use of electricity.

- **NEMA**
  This organization establishes certain voluntary industry standards relating to motors; such as operating characteristics, terminology, basic dimensions, ratings and testing. NEMA refers to the National Electrical Manufacturers Association. NEMA is part of the IEC. NEMA is made up of well-known North American electrical suppliers.

- **PHASES (PH)**
  Indicates whether the motor operates from single or three phase electricity.

- **Poles**
  Poles are the number of sets of three-way electromagnetic windings that a motor has. In the simplest three-phase motor, there are 3 separate electromagnets formed by the single set of three-way windings. Thus, there is a set of North-South electromagnetic poles formed. This motor is said to have "2 poles" .
  The next most complex motor has two sets of three phase windings, and is called a "4-pole motor". It is the most common motor produced, and has a 60 Hertz base speed of 1800 rpm. 6-pole motors operate at 1200 rpm.

- **Power Factor**
  The ratio of the kilowatt input to the kVA input and is usually expressed as a percentage.

- **Rotor**
  The rotating element of a motor.

- **RPM (Revolutions per Minute)**
  The number of times each minute that the shaft of a motor turns on its axis. Typical values are 980, 1160, 1450, 1750, 1450, 3450, etc. If more than one speed is listed, this indicates a multi-speed motor.

- **Serial Number (Ser.) (S/N)**
  The serial number helps the manufacturer determine when the motor was manufactured, this helps determine which set of drawings or parts list to use.

- **Service Factor (SF)**
  The amount a motor can be overloaded without damage or overheating. A motor with a 1.15 service factor can safely operate at 15% over the nameplate horsepower.

  Note: At 115% of rated horsepower, a motor can be expected to run 10°C hotter than the standard limit applicable to rated load. 10°C higher temperature cuts insulation thermal life in half. That means a motor running continuously at the service factor overload will have greatly reduced life.

- **Stall or Locked Rotor Time**
  Time in seconds that a motor can withstand locked rotor (stalled) current without damage.

- **Star (Wye) Winding**
  Many motors have two different ways of connecting the windings to three phase power. For further information's pls. refer to the chapter "TERMINAL MARKINGS AND CONNECTIONS".

- **Terminal Box**
  Contains the motor leads and/or the terminals for connection to power source.

- **Thermal Protection**
  The main adverse effect of overheated motors is the breakdown of insulation caused by excessive temperatures. Eventually, poor insulation leads to electrical shorts in the windings. Under rare conditions, overheated motors can also cause fires. Many motors today, particularly the more expensive motors, are built with temperature sensors which allow monitoring of winding temperatures and allow for automatic shutdown if desired.

- **Torque**
  Twisting or turning force produced by motor.
  Starting Torque (Locked Rotor Torque): - The amount of turning force produced by a motor as it begins to turn from standstill and accelerate.
  Full-Load Torque: - This is the amount of torque produced by a motor when it is running at rated full-load speed at rated horsepower

- **Type**
  Mod. (Model), Tp. (Type), or Cat. (Catalogue), this is the number that you need if you want to contact the manufacturer for ordering parts, etc.

- **UL (Underwriters Laboratories, Inc.)**
  An independent testing organization that sets safety standards for motors and other electrical equipment.

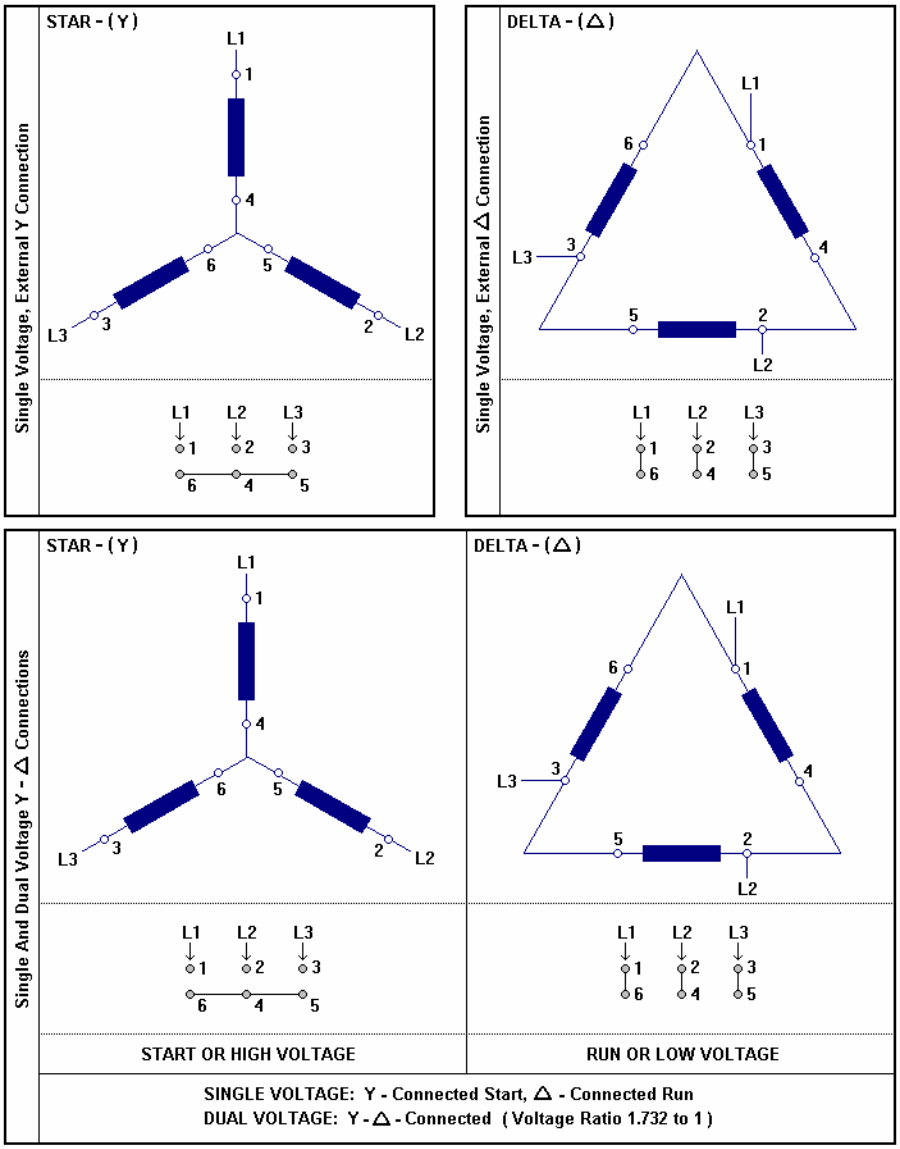
- **Voltage** …unit of electromotive force
  The operating voltage of the motor. Typically voltages for AC motors are 115, 230, 380, 400, 440, 480, 575, 660, 690.

- **Watts** …unit of electrical power
  Output power rating of the motor. American made motors or older British or Canadian motors, will probably be rated in Horsepower. European and Asian motors are usually rated in kilowatts.
  746 watts = 0.746 kW = 1 horsepower (HP) or 1 HP = 3/4 kW (0.746 kW).

- **Wye (Star) Winding**
  Many motors have two different ways of connecting the windings to three phase power. For further information's pls. refer to the chapter "TERMINAL MARKINGS AND CONNECTIONS".

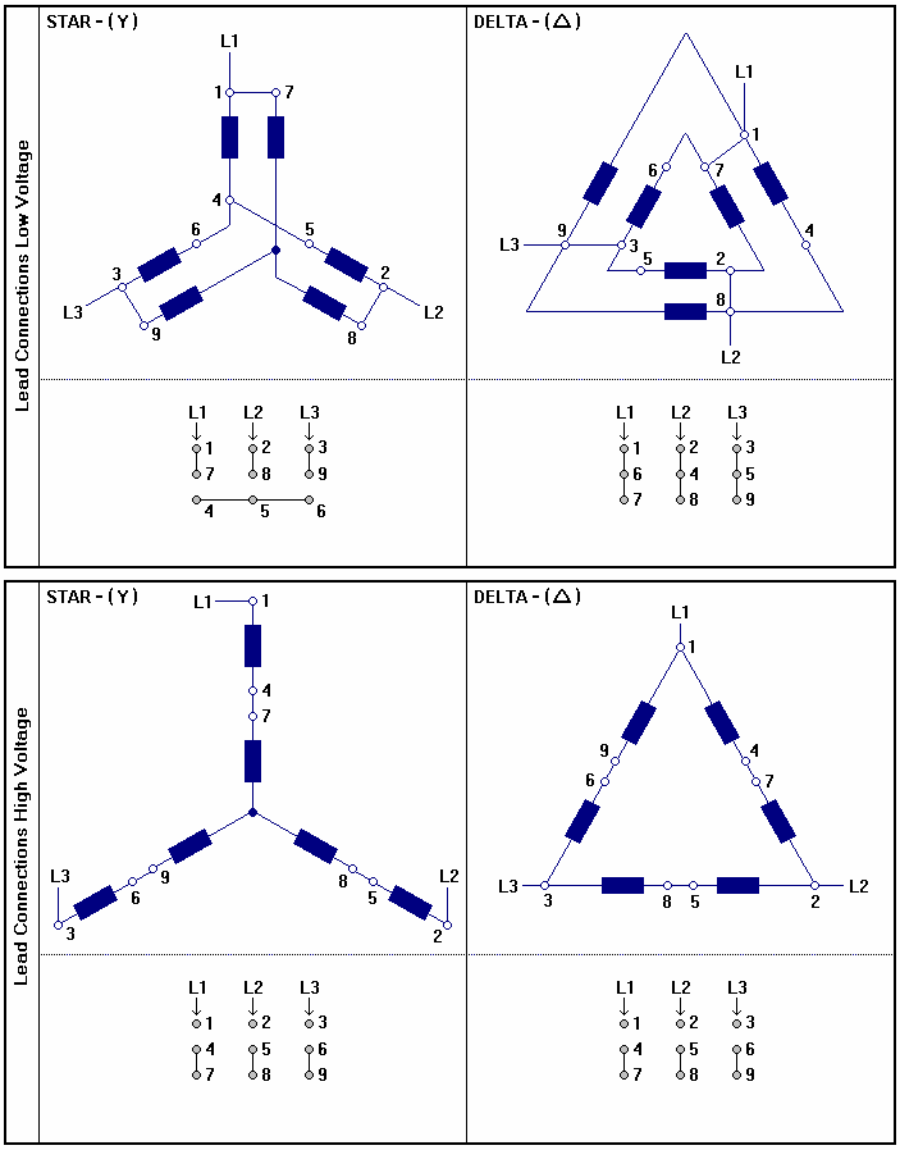
TERMINAL MARKINGS AND CONNECTIONS

FOR NEMA SINGLE-SPEED THREE-PHASE INDUCTION MOTORS – 6 LEADS



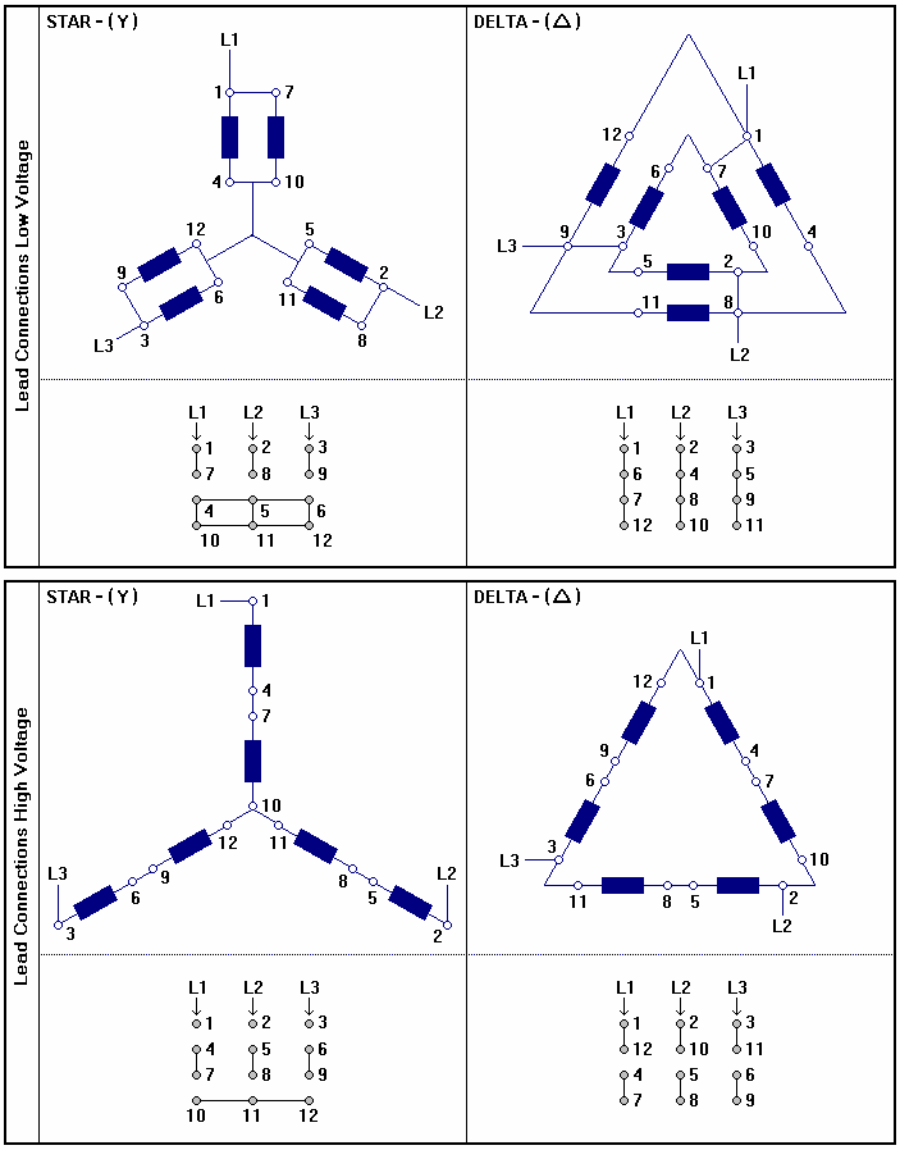
TERMINAL MARKINGS AND CONNECTIONS

FOR NEMA SINGLE-SPEED THREE-PHASE INDUCTION MOTORS – 9 LEADS



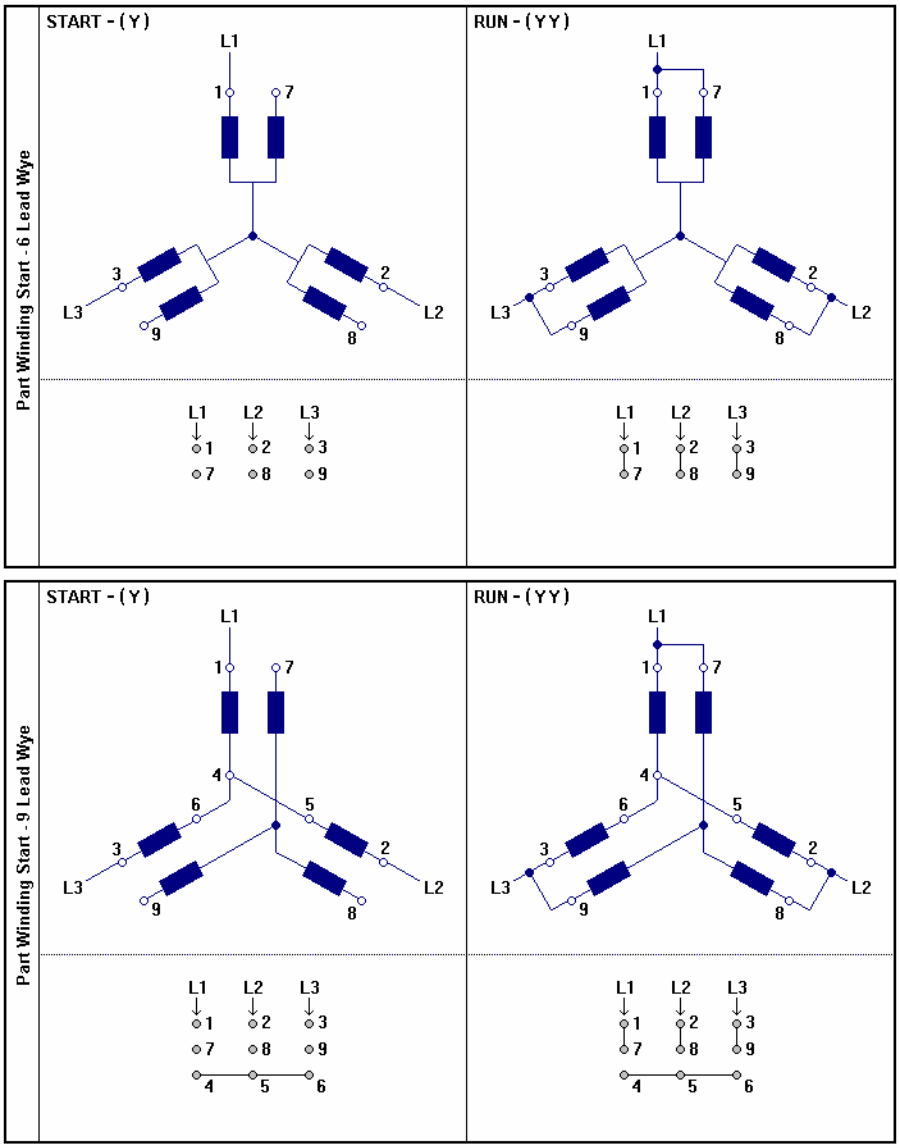
TERMINAL MARKINGS AND CONNECTIONS

FOR NEMA SINGLE-SPEED THREE-PHASE INDUCTION MOTORS – 12 LEADS



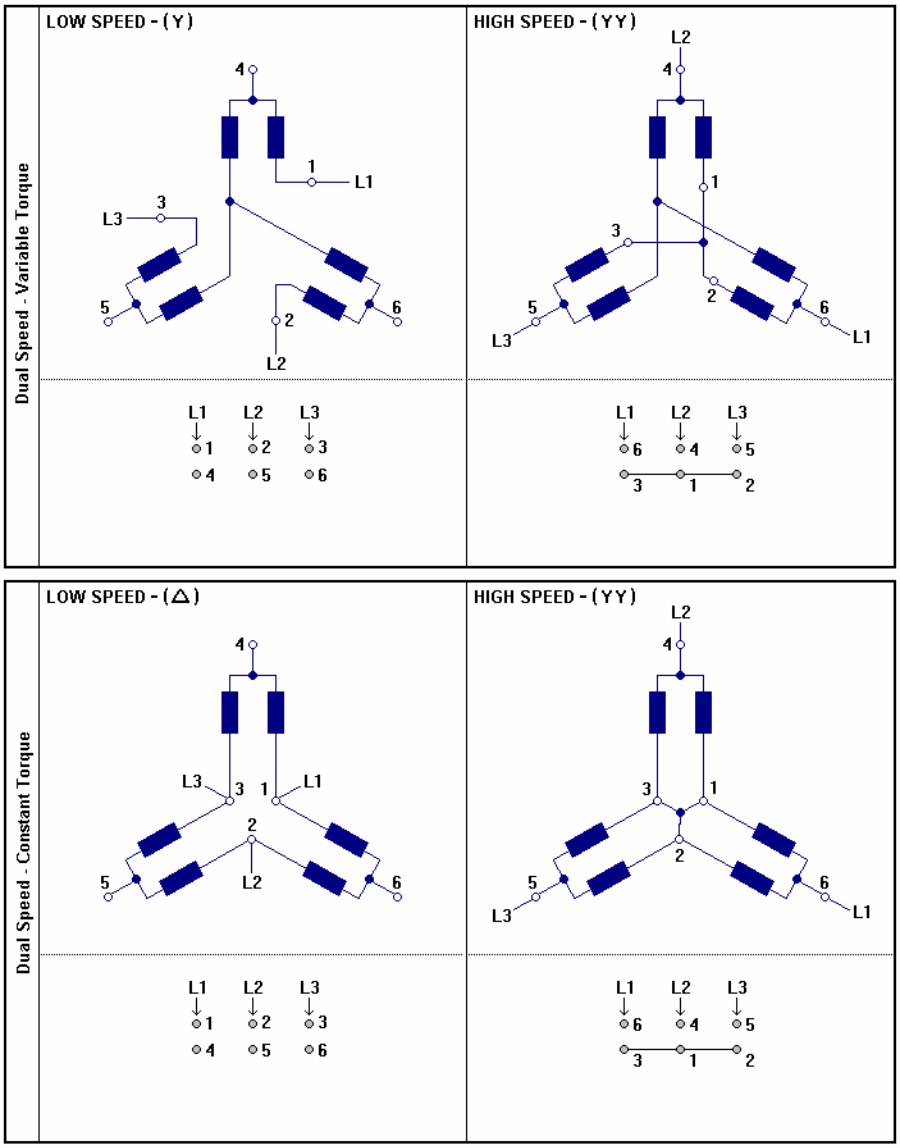
TERMINAL MARKINGS AND CONNECTIONS

FOR NEMA SINGLE-SPEED THREE-PHASE INDUCTION MOTORS – 6 & 9 LEADS PART-WINDING-START



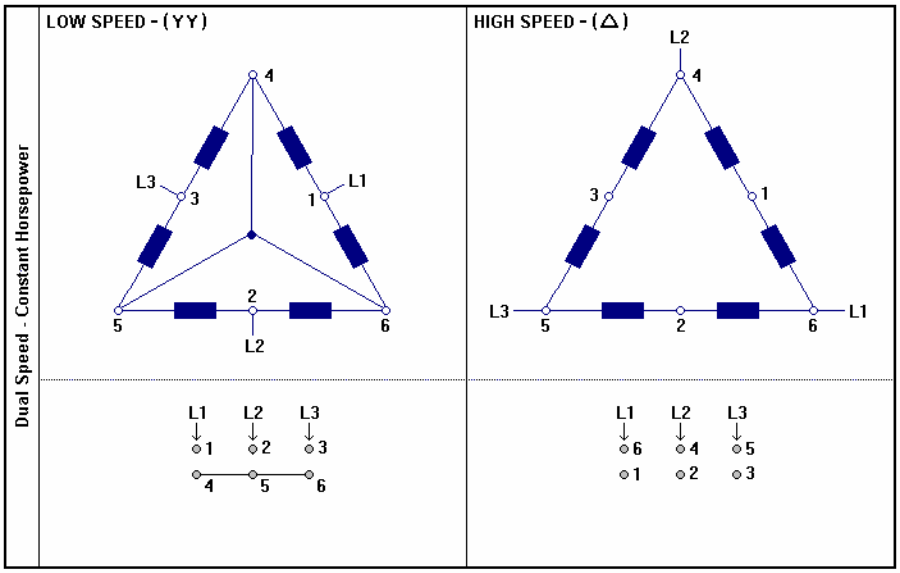
TERMINAL MARKINGS AND CONNECTIONS

FOR NEMA DUAL-SPEED THREE-PHASE INDUCTION MOTORS



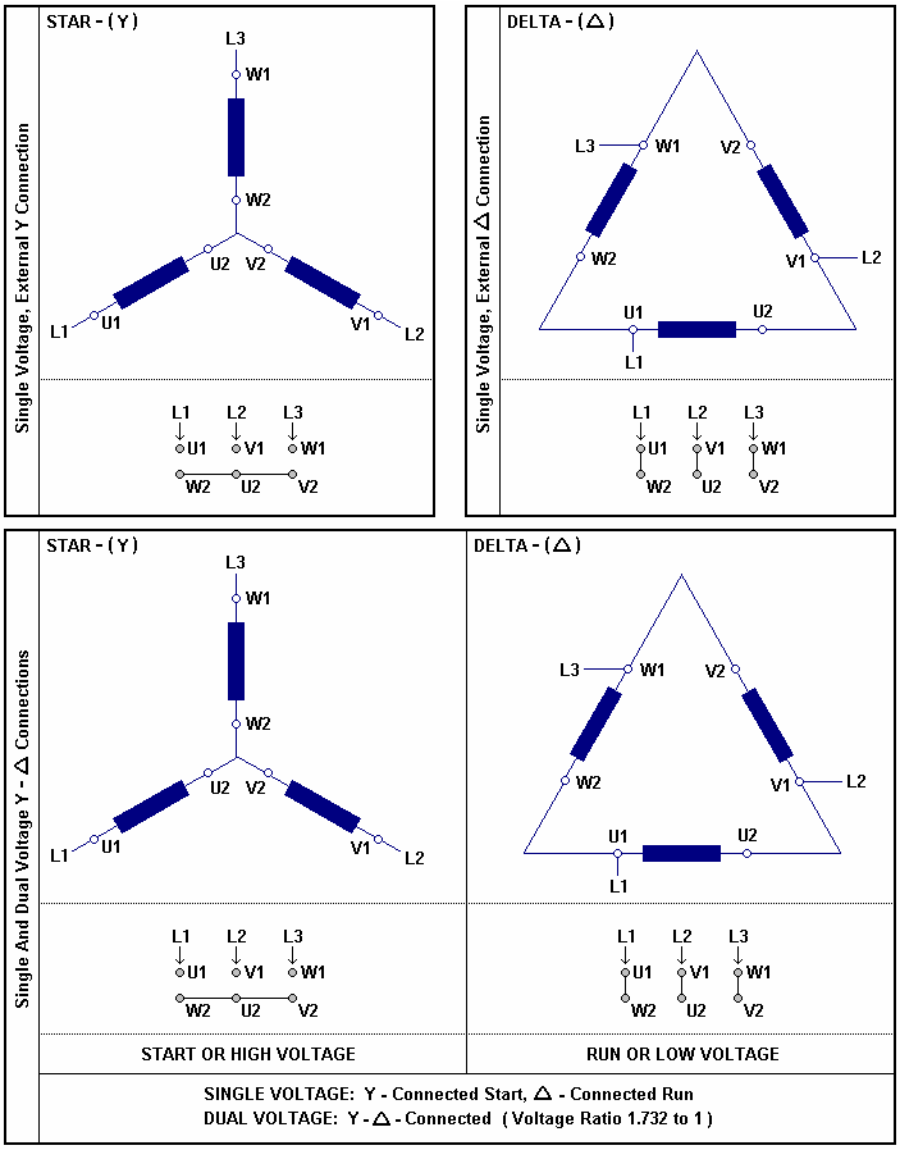
TERMINAL MARKINGS AND CONNECTIONS

FOR NEMA DUAL-SPEED THREE-PHASE INDUCTION MOTORS



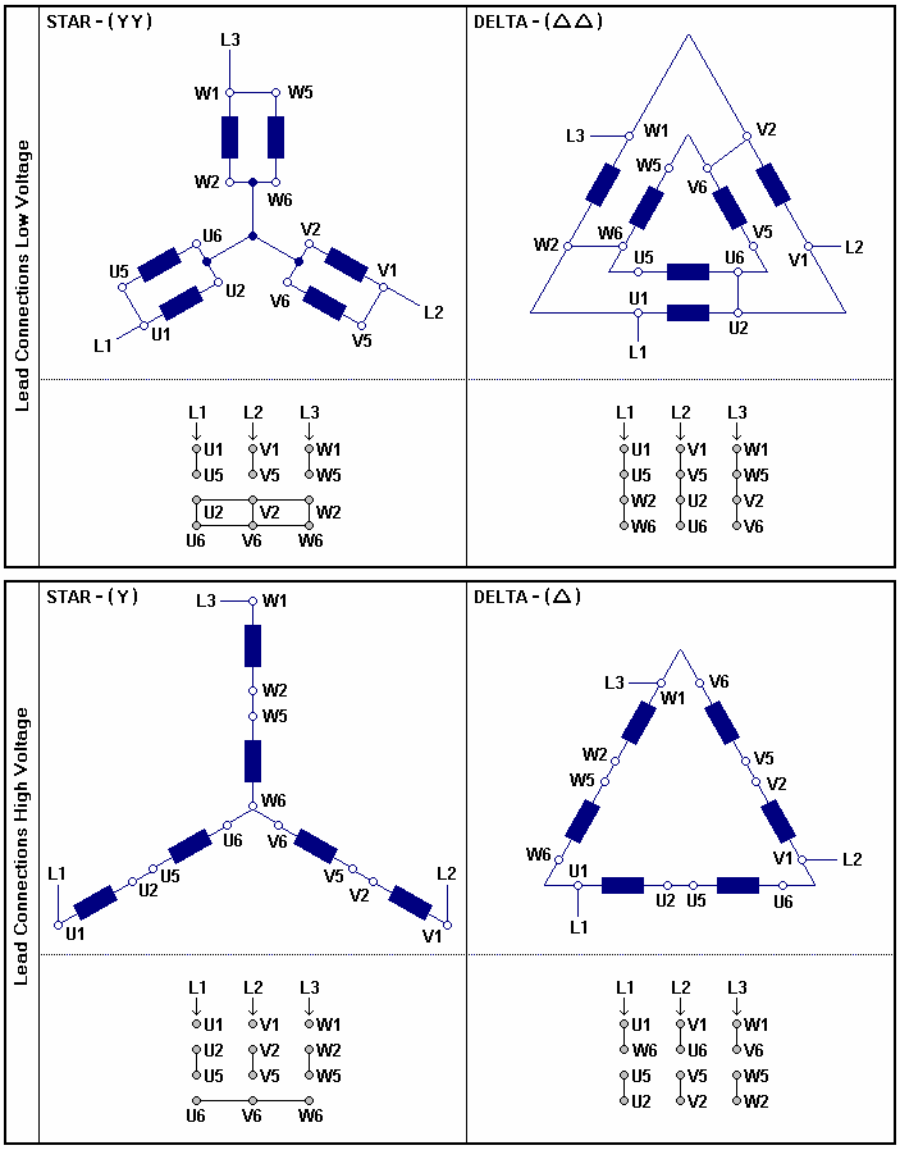
TERMINAL MARKINGS AND CONNECTIONS

FOR IEC SINGLE-SPEED THREE-PHASE INDUCTION MOTORS – 6 LEADS



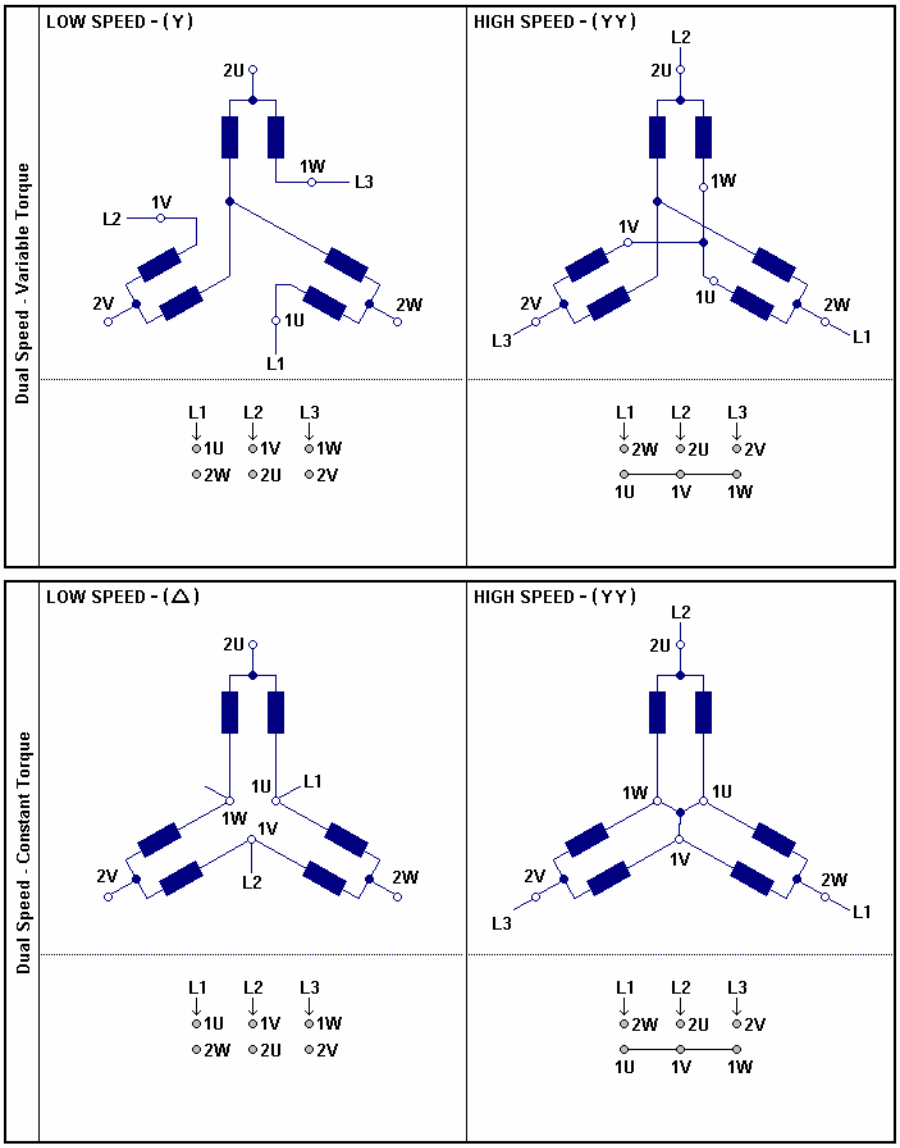
TERMINAL MARKINGS AND CONNECTIONS

FOR IEC SINGLE-SPEED THREE-PHASE INDUCTION MOTORS – 12 LEADS



TERMINAL MARKINGS AND CONNECTIONS

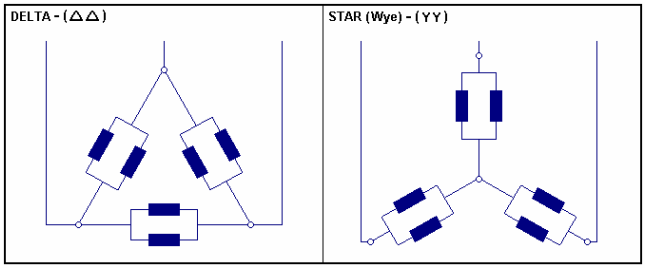
FOR IEC DUAL-SPEED THREE-PHASE INDUCTION MOTORS



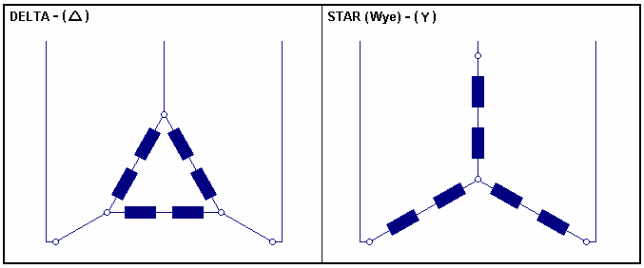
LOW AND HIGH VOLTAGE CONNECTIONS

FOR THREE-PHASE INDUCTION MOTORS

Low Voltage Connections



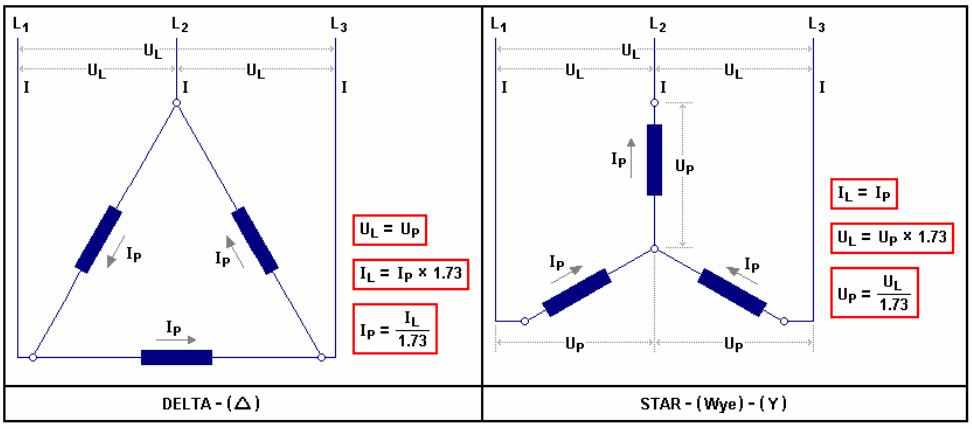
High Voltage Connections



LV - Delta	LV - Wye	HV - Delta	HV - Wye
110 V	190 V	220 V	380 V
120 V	208 V	240 V	415 V
125 V	220 V	250 V	440 V
133 V	230 V	266 V	460 V
140 V	240 V	277 V	480 V
166 V	288 V	335 V	575 V
190 V	330 V	380 V	660 V
200 V	345 V	400 V	690 V
220 V	380 V	440 V	760 V
250 V	440 V	500 V	865 V

HV = 2 x LV

Wye = 1.73 x Delta



Voltage	Current
$U_L = U_{Line-To-Line}$	$I_L = I_{Line}$
$U_P = U_{Phase}$	$I_P = I_{Phase}$

FRAME ASSIGNMENTS

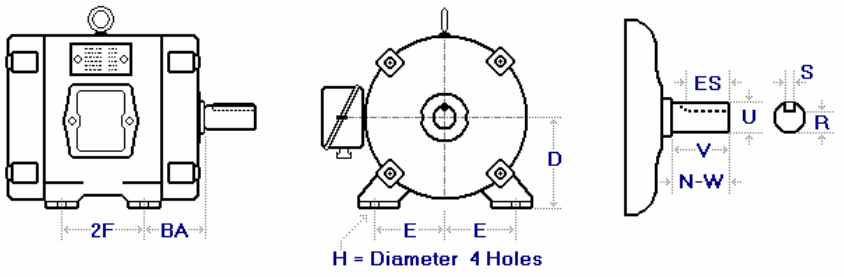
FOR NEMA THREE-PHASE INDUCTION MOTORS

HP	3600 RPM			1800 RPM			1200 RPM			900 RPM		
	orig.	1952 rerate	1964 rerate	orig.	1952 rerate	1964 rerate	orig.	1952 rerate	1964 rerate	orig.	1952 rerate	1964 rerate
1	-	-	-	203	182	143T	204	184	145T	225	213	182T
1-1/2	203	182	143T	204	184	145T	224	184	182T	254	213	184T
2	204	184	145T	224	184	145T	225	213	184T	254	215	213T
3	224	184	182T	225	213	182T	254	215	213T	284	254U	215T
5	225	213	184T	254	215	184T	284	254U	215T	324	256U	254T
7-1/2	254	215	213T	284	254U	213T	324	256U	254T	326	284U	256T
10	284	254U	215T	324	256U	215T	326	284U	256T	364	286U	284T
15	324	256U	254T	326	284U	254T	364	324U	284T	365	326U	286T
20	326	286U	256T	364	286U	256T	365	326U	286T	404	364U	324T
25	365S	324U	284TS	365	324U	284T	404	364U	324T	405	365U	326T
30	404S	326S	286TS	404	326U	286T	405	365U	326T	444	404U	364T
40	405S	364US	324TS	405	364U	324T	444	404U	364T	445	405U	365T
50	444S	365US	326TS	444S	365US	326T	445	405U	365T	504U	444U	404T
60	445S	405US	364TS	445S	405US	364TS*	504U	444U	404T	505	445U	405T
75	504S	444US	365TS	504S	444US	365TS*	505	445U	405T	-	-	444T
100	505S	445US	405TS	505S	445US	405TS*	-	-	444T	-	-	445T
125	-	-	444TS	-	-	444TS*	-	-	445T	-	-	-
150	-	-	445TS	-	-	445TS*	-	-	-	-	-	-

*…. *when motors are to be used with V-belt or chain drives, the correct frame size is the frame size shown but with the suffix letter* (S) *omitted. For the corresponding shaft extension dimensions, see next two pages.*

FRAME DIMENSIONS

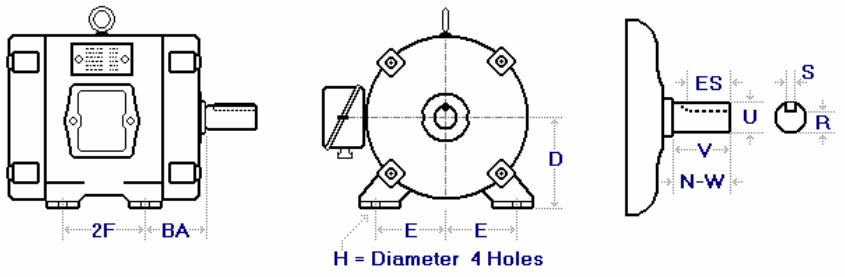
FOR NEMA THREE-PHASE
INDUCTION MOTORS



Frame Design.	D	E	2F	BA	H	U	N-W	V min	R	ES min	S
42	2.62	1.75	1.69	2.06	0.28	0.375	1.12		0.328		flat
48	3.00	2.12	2.75	2.50	0.34	0.500	1.50		0.453		flat
48H	3.00	2.12	4.75	2.50	0.34	0.500	1.50		0.453		flat
56	3.50	2.44	3.00	2.75	0.34	0.625	1.88		0.517	1.41	0.188
56H	3.50	2.44	5.00	2.75	0.34	0.625	1.88		0.517	1.41	0.188
66	4.12	2.94	5.00	3.12	0.41	0.750	2.25		0.644	1.91	0.188
143	3.50	2.75	4.00	2.25	0.34	0.750	2.00	1.75	0.644	1.41	0.188
143T	3.50	2.75	4.00	2.25	0.34	0.875	2.25	2.00	0.771	1.41	0.188
145	3.50	2.75	5.00	2.25	0.34	0.750	2.00	1.75	0.644	1.41	0.188
145T	3.50	2.75	5.00	2.25	0.34	0.875	2.25	2.00	0.771	1.41	0.188
182	4.50	3.75	4.50	2.75	0.41	0.875	2.25	2.00	0.771	1.41	0.188
182T	4.50	3.75	4.50	2.75	0.41	1.125	2.75	2.50	0.986	1.78	0.250
184	4.50	3.75	5.50	2.75	0.41	0.875	2.25	2.00	0.771	1.41	0.188
184T	4.50	3.75	5.50	2.75	0.41	1.125	2.75	2.50	0.986	1.76	0.250
203	5.00	4.00	5.50	3.12	0.41	0.750	2.25	2.00	0.644	1.53	0.188
204	5.00	4.00	6.50	3.12	0.41	0.750	2.25	2.00	0.644	1.53	0.188
213	5.25	4.25	5.50	3.50	0.41	1.125	3.00	2.75	0.986	2.03	0.250
213T	5.25	4.25	5.50	3.50	0.41	1.375	3.38	3.12	1.201	2.41	0.312
215	5.25	4.25	7.00	3.50	0.41	1.125	3.00	2.75	0.986	2.03	0.250
215T	5.25	4.25	7.00	3.50	0.41	1.375	3.38	3.12	1.201	2.41	0.312
224	5.50	4.50	6.75	3.50	0.41	1.000	3.00	2.75	0.859	2.03	0.250
225	5.50	4.50	7.50	3.50	0.41	1.000	3.00	2.75	0.859	2.03	0.250
254	6.25	5.00	8.25	4.25	0.53	1.125	3.38	3.12	0.986	2.03	0.250
254U	6.25	5.00	8.25	4.25	0.53	1.375	3.75	3.50	1.201	2.78	0.312
254T	6.25	5.00	8.25	4.25	0.53	1.625	4.00	3.75	1.416	2.91	0.375
256U	6.25	5.00	10.00	4.25	0.53	1.375	3.75	3.50	1.201	2.78	0.312
256T	6.25	5.00	10.00	4.25	0.53	1.625	4.00	3.75	1.416	2.91	0.375
284	7.00	5.50	9.50	4.75	0.53	1.250	3.75	3.50	1.112	2.03	0.250
284U	7.00	5.50	9.50	4.75	0.53	1.625	4.88	4.62	1.416	3.78	0.375
284T	7.00	5.50	9.50	4.75	0.53	1.875	4.62	4.38	1.591	3.28	0.500
284TS	7.00	5.50	9.50	4.75	0.53	1.625	3.25	3.00	1.416	1.91	0.375
286U	7.00	5.50	11.00	4.75	0.53	1.625	4.88	4.62	1.416	3.78	0.375
286T	7.00	5.50	11.00	4.75	0.53	1.875	4.62	4.38	1.591	3.28	0.500
286TS	7.00	5.50	11.00	4.75	0.53	1.625	3.25	3.00	1.416	1.91	0.375
324	8.00	6.25	10.50	5.25	0.66	1.625	4.88	4.62	1.416	3.78	0.375
324U	8.00	6.25	10.50	5.25	0.66	1.875	5.62	5.38	1.591	4.28	0.500
324S	8.00	6.25	10.50	5.25	0.66	1.625	3.25	3.00	1.416	1.91	0.375
324T	8.00	6.25	10.50	5.25	0.66	2.125	5.25	5.00	1.845	3.91	0.500
324TS	8.00	6.25	10.50	5.25	0.66	1.875	3.75	3.50	1.591	2.03	0.500
326	8.00	6.25	12.00	5.25	0.66	1.625	4.88	4.62	1.416	3.78	0.375
326U	8.00	6.25	12.00	5.25	0.66	1.875	5.62	5.38	1.591	4.28	0.500
326S	8.00	6.25	12.00	5.25	0.66	1.625	3.25	3.00	1.416	1.91	0.375
326T	8.00	6.25	12.00	5.25	0.66	2.125	5.25	5.00	1.845	3.91	0.500

FRAME DIMENSIONS

FOR NEMA THREE-PHASE
INDUCTION MOTORS



Frame Design.	D	E	2F	BA	H	U	N-W	V min	R	ES min	S
364	9.00	7.00	11.25	5.88	0.66	1.875	5.62	5.38	1.591	4.28	0.500
364S	9.00	7.00	11.25	5.88	0.66	1.625	3.25	3.00	1.416	1.91	0.375
364U	9.00	7.00	11.25	5.88	0.66	2.125	6.38	6.12	1.845	5.03	0.500
364US	9.00	7.00	11.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
364T	9.00	7.00	11.25	5.88	0.66	2.375	5.88	5.62	2.021	4.28	0.625
364TS	9.00	7.00	11.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
365	9.00	7.00	12.25	5.88	0.66	1.875	5.62	5.38	1.591	4.28	0.500
365S	9.00	7.00	12.25	5.88	0.66	1.625	3.25	3.00	1.416	1.91	0.375
365U	9.00	7.00	12.25	5.88	0.66	2.125	6.38	6.12	1.845	5.03	0.500
365US	9.00	7.00	12.25	5.88	0.66	1.875	3.76	3.50	1.591	2.03	0.500
365T	9.00	7.00	12.25	5.88	0.66	2.375	5.88	5.62	2.021	4.28	0.625
365TS	9.00	7.00	12.25	5.88	0.66	1.875	3.75	3.50	1.591	2.03	0.500
404	10.00	8.00	12.25	6.62	0.81	2.125	6.38	6.12	1.845	5.03	0.500
404S	10.00	8.00	12.25	6.62	0.81	1.875	3.75	3.50	1.591	2.03	0.500
404U	10.00	8.00	12.25	6.62	0.81	2.375	7.12	6.88	2.021	5.53	0.625
404US	10.00	8.00	12.25	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
404T	10.00	8.00	12.25	6.62	0.81	2.875	7.25	7.00	2.450	5.65	0.750
404TS	10.00	8.00	12.25	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
405	10.00	8.00	13.75	6.62	0.81	2.125	6.38	6.12	1.845	5.03	0.500
405S	10.00	8.00	13.75	6.62	0.81	1.875	3.75	3.50	1.591	2.03	0.500
405U	10.00	8.00	13.75	6.62	0.81	2.375	7.12	6.88	2.021	5.53	0.625
405US	10.00	8.00	13.75	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
405T	10.00	8.00	13.75	6.62	0.81	2.875	7.25	7.00	2.450	5.65	0.750
405TS	10.00	8.00	13.75	6.62	0.81	2.125	4.25	4.00	1.845	2.78	0.500
444	11.00	9.00	14.50	7.50	0.81	2.375	7.12	6.88	2.021	5.53	0.625
444S	11.00	9.00	14.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
444U	11.00	9.00	14.50	7.50	0.81	2.875	8.62	8.38	2.450	7.03	0.750
444US	11.00	9.00	14.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
444T	11.00	9.00	14.50	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
444TS	11.00	9.00	14.50	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
445	11.00	9.00	16.50	7.50	0.81	2.375	7.12	6.88	2.021	5.53	0.625
445S	11.00	9.00	16.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
445U	11.00	9.00	16.50	7.50	0.81	2.875	8.62	8.38	2.450	7.03	0.750
445US	11.00	9.00	16.50	7.50	0.81	2.125	4.25	4.00	1.845	2.78	0.500
445T	11.00	9.00	16.50	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
445TS	11.00	9.00	16.50	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
447T	11.00	9.00	20.00	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
447TS	11.00	9.00	20.00	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
449T	11.00	9.00	25.00	7.50	0.81	3.375	8.50	8.25	2.880	6.91	0.875
449TS	11.00	9.00	25.00	7.50	0.81	2.375	4.75	4.50	2.021	3.03	0.625
504U	12.50	10.00	16.00	8.50	0.94	2.875	8.62	8.38	2.450	7.28	0.750
504S	12.50	10.00	16.00	8.50	0.94	2.125	4.25	4.00	1.845	2.78	0.500
505	12.50	10.00	18.00	8.50	0.94	2.875	8.62	8.38	2.450	7.28	0.750
505S	12.50	10.00	18.00	8.50	0.94	2.125	4.25	4.00	1.845	2.78	0.500

BEARINGS

	Bore	Dia	W	#
600 SERIES	3 mm	10 mm	4 mm	623
	4 mm	9 mm	2.5 mm	618/4
	4 mm	13 mm	5 mm	624
	4 mm	16 mm	5 mm	634
	5 mm	16 mm	5 mm	625
	5 mm	19 mm	6 mm	635
	6 mm	13 mm	3.5 mm	618/6
	6 mm	19 mm	6 mm	626
	7 mm	14 mm	3.5 mm	618/7
	7 mm	19 mm	6 mm	607
	7 mm	22 mm	7 mm	627
	8 mm	16 mm	4 mm	618/8
	8 mm	22 mm	7 mm	608
	8 mm	24 mm	8 mm	628
	9 mm	24 mm	7 mm	609
	9 mm	26 mm	8 mm	629
6000 SERIES	10 mm	26 mm	8 mm	6000
	12 mm	28 mm	8 mm	6001
	15 mm	32 mm	9 mm	6002
	17 mm	35 mm	10 mm	6003
	20 mm	42 mm	12 mm	6004
	25 mm	47 mm	12 mm	6005
	30 mm	55 mm	13 mm	6006
	35 mm	62 mm	14 mm	6007
	40 mm	68 mm	15 mm	6008
	45 mm	75 mm	16 mm	6009
	50 mm	80 mm	16 mm	6010
	55 mm	90 mm	18 mm	6011
	60 mm	95 mm	18 mm	6012
	65 mm	100 mm	18 mm	6013
	70 mm	110 mm	20 mm	6014
	80 mm	125 mm	22 mm	6016
	90 mm	140 mm	24 mm	6018
	100 mm	150 mm	24 mm	6020
6200 SERIES	10 mm	30 mm	9 mm	6200
	12 mm	32 mm	10 mm	6201
	15 mm	35 mm	11 mm	6202
	17 mm	40 mm	12 mm	6203
	20 mm	47 mm	14 mm	6204
	25 mm	52 mm	15 mm	6205
	30 mm	62 mm	16 mm	6206
	35 mm	72 mm	17 mm	6207
	40 mm	80 mm	18 mm	6208
	45 mm	85 mm	19 mm	6209
	50 mm	90 mm	20 mm	6210
	55 mm	100 mm	21 mm	6211
	60 mm	110 mm	22 mm	6212
	65 mm	120 mm	23 mm	6213
	70 mm	125 mm	24 mm	6214
	80 mm	140 mm	26 mm	6216
	90 mm	160 mm	30 mm	6218
	100 mm	180 mm	34 mm	6220

	Bore	Dia	W	#
6300 SERIES	10 mm	35 mm	11 mm	6300
	12 mm	37 mm	12 mm	6301
	15 mm	42 mm	13 mm	6302
	20 mm	47 mm	14 mm	6303
	20 mm	52 mm	15 mm	6304
	25 mm	62 mm	17 mm	6305
	30 mm	72 mm	19 mm	6306
	35 mm	80 mm	21 mm	6307
	40 mm	90 mm	23 mm	6308
	45 mm	100 mm	25 mm	6309
	50 mm	110 mm	27 mm	6310
	55 mm	120 mm	29 mm	6311
	60 mm	130 mm	31 mm	6312
	65 mm	140 mm	33 mm	6313
	70 mm	150 mm	35 mm	6314
	80 mm	170 mm	39 mm	6316
	90 mm	190 mm	43 mm	6318
	100 mm	215 mm	47 mm	6320

R (INCH) SERIES	0.1875"	0.5000"	0.1960"	RA3
	0.2500"	0.6250"	0.1960"	R4
	0.2500"	0.7500"	0.2812"	RA4
	0.3750"	0.8750"	0.2812"	R6
	0.5000"	1.1250"	0.3125"	R8
	0.6250"	1.3750"	0.3437"	R10
	0.7500"	1.6250"	0.4375"	R12
	0.8750"	1.8750"	0.5000"	R14
	1.0000"	2.0000"	0.5000"	R16
	1.1250"	2.1250"	0.5000"	R18
	1.2500"	2.2500"	0.5000"	R20

Double Sealed					
SKF	FAG	NTN	NSK	SNR	KOYO
-2RS	-2RS	LLB	W	EE	-2RS

Double Shielded					
SKF	FAG	NTN	NSK	SNR	KOYO
-2Z	-2Z	ZZ	ZZ	ZZ	ZZ

For example: …double shielded SKF bearing: 6311-2Z
…double shielded SNR bearing: 6311-ZZ

…double sealed SKF bearing: 6311-2RS
…double sealed SNR bearing: 6311-EE

FULL LOAD CURRENTS

FOR NEMA THREE-PHASE INDUCTION MOTORS

HP	RPM	230 V	460 V	575 V
1/4	1800	0.95 A	0.48 A	0.38 A
	1200	1.40 A	0.70 A	0.56 A
	900	1.60 A	0.80 A	0.64 A
1/3	1800	1.19 A	0.68 A	0.48 A
	1200	1.59 A	0.80 A	0.64 A
	900	1.80 A	0.90 A	0.72 A
1/2	1800	1.72 A	0.86 A	0.69 A
	1200	2.15 A	1.08 A	0.86 A
	900	2.38 A	1.19 A	0.95 A
3/4	1800	2.46 A	1.23 A	0.98 A
	1200	2.92 A	1.46 A	1.17 A
	900	3.26 A	1.63 A	1.30 A
1	3600	2.80 A	1.40 A	1.12 A
	1800	3.56 A	1.78 A	1.42 A
	1200	3.76 A	1.88 A	1.50 A
	900	4.30 A	2.15 A	1.72 A
1-1/2	3600	4.36 A	2.18 A	1.74 A
	1800	4.86 A	2.43 A	1.94 A
	1200	5.28 A	2.64 A	2.11 A
	900	5.60 A	2.80 A	2.24 A
2	3600	5.60 A	2.80 A	2.24 A
	1800	6.40 A	3.20 A	2.56 A
	1200	6.84 A	3.42 A	2.74 A
	900	7.90 A	3.95 A	3.16 A
3	3600	8.34 A	4.17 A	3.34 A
	1800	9.40 A	4.70 A	3.76 A
	1200	10.2 A	5.12 A	4.10 A
	900	11.4 A	5.70 A	4.55 A
5	3600	13.5 A	6.76 A	5.41 A
	1800	14.4 A	7.21 A	5.78 A
	1200	15.8 A	7.91 A	6.32 A
	900	15.9 A	7.92 A	6.33 A
7-1/2	3600	19.5 A	9.79 A	7.81 A
	1800	21.5 A	10.7 A	8.55 A
	1200	21.8 A	10.9 A	8.70 A
	900	23.0 A	11.5 A	9.19 A
10	3600	25.4 A	12.7 A	10.1 A
	1800	26.8 A	13.4 A	10.7 A
	1200	28.0 A	14.0 A	11.2 A
	900	30.5 A	15.2 A	12.2 A
15	3600	36.4 A	18.2 A	14.5 A
	1800	39.2 A	19.6 A	15.7 A
	1200	41.4 A	20.7 A	16.5 A
	900	44.5 A	22.2 A	17.8 A

HP	RPM	230 V	460 V	575 V
20	3600	50.4 A	25.2 A	20.1 A
	1800	51.2 A	25.6 A	20.5 A
	1200	52.8 A	26.4 A	21.1 A
	900	54.9 A	27.4 A	21.9 A
25	3600	60.8 A	30.4 A	24.3 A
	1800	64.8 A	32.4 A	25.9 A
	1200	65.6 A	32.8 A	26.2 A
	900	67.3 A	33.7 A	27.0 A
30	3600	73.7 A	36.8 A	29.4 A
	1800	75.6 A	37.8 A	30.2 A
	1200	78.8 A	39.4 A	31.5 A
	900	81.8 A	40.9 A	32.7 A
40	3600	96.4 A	48.2 A	38.5 A
	1800	101 A	50.4 A	40.3 A
	1200	102 A	50.6 A	40.4 A
	900	105 A	52.2 A	41.7 A
50	3600	120 A	60.1 A	48.2 A
	1800	124 A	62.2 A	49.7 A
	1200	126 A	63.0 A	50.4 A
	900	130 A	65.0 A	52.0 A
60	3600	143 A	71.7 A	57.3 A
	1800	149 A	74.5 A	59.4 A
	1200	150 A	75.0 A	60.0 A
	900	154 A	77.0 A	61.5 A
75	3600	179 A	89.6 A	71.7 A
	1800	183 A	91.6 A	73.2 A
	1200	184 A	92.0 A	73.5 A
	900	193 A	96.5 A	77.5 A
100	3600	231 A	115 A	92.2 A
	1800	236 A	118 A	94.8 A
	1200	239 A	120 A	95.6 A
	900	252 A	126 A	101 A
125	3600	292 A	146 A	116 A
	1800	293 A	147 A	117 A
	1200	298 A	149 A	119 A
	900	305 A	153 A	122 A
150	3600	343 A	171 A	137 A
	1800	348 A	174 A	139 A
	1200	350 A	175 A	141 A
	900	365 A	183 A	146 A
200	3600	452 A	226 A	181 A
	1800	458 A	229 A	184 A
	1200	460 A	230 A	185 A
	900	482 A	241 A	193 A

MAXIMUM LOCKED-ROTOR CURRENTS

FOR NEMA THREE-PHASE INDUCTION MOTORS

HP	230V	460V	575V
1/2	20.0 A	10.0 A	8.0 A
3/4	25.0 A	12.5 A	10.0 A
1	30.0 A	15.0 A	12.0 A
1 1/2	40.0 A	20.0 A	16.0 A
2	50.0 A	25.0 A	20.0 A
3	64.0 A	32.0 A	25.0 A
5	92.0 A	46.0 A	37.0 A
7 1/2	127.0 A	63.0 A	51.0 A
10	162.0 A	81.0 A	65.0 A
15	232.0 A	116.0 A	93.0 A
20	290.0 A	145.0 A	116.0 A
25	365.0 A	182.0 A	146.0 A
30	435.0 A	217.0 A	174.0 A
40	580.0 A	290.0 A	232.0 A
50	725.0 A	362.0 A	290.0 A
60	870.0 A	435.0 A	348.0 A
75	1085.0 A	592.0 A	435.0 A
100	1450.0 A	725.0 A	580.0 A
125	1815.0 A	907.0 A	726.0 A
150	2170.0 A	1085.0 A	870.0 A
200	2900.0 A	1450.0 A	1160.0 A
250	3650.0 A	1825.0 A	1460.0 A

CODE LETTERS

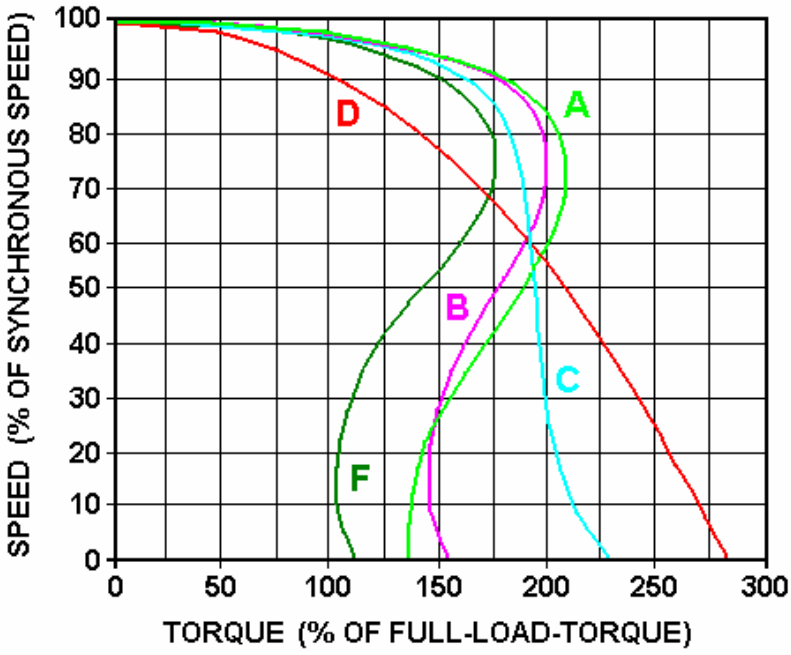
FOR NEMA THREE-PHASE INDUCTION MOTORS

NEMA CODE LETTER	LOCKED ROTOR kVA per hp	NEMA CODE LETTER	LOCKED ROTOR kVA per hp	NEMA CODE LETTER	LOCKED ROTOR kVA per hp
A	0 - 3.14	H	6.30 - 7.09	R	14.00 - 15.99
B	3.15 - 3.54	J	7.10 - 7.99	S	16.00 - 17.99
C	3.55 - 3.99	K	8.00 - 8.99	T	18.00 - 19.99
D	4.00 - 4.49	L	9.00 - 9.99	U	20.00 - 22.39
E	4.50 - 4.99	M	10.0 - 11.19	V	22.40 - up
F	5.00 - 5.59	N	11.20 - 12.49		
G	5.60 - 6.29	P	12.50 - 13.99		

$$\text{START kVA per Hp} = \frac{\text{VOLTS X LOCKED-ROTOR-AMPS}}{\text{Hp X 1000}} \text{ X } 1.732$$

SPEED-TORQUE CHARACTERISTICS

FOR NEMA THREE-PHASE INDUCTION MOTORS



	NEMA DESIGN	STARTING CURRENT	LOCKED ROTOR	BREAKDOWN TORQUE	SLIP
	A	Medium	Medium Torque	High	2% - 5%
	B	Low	Medium Torque	High	2% - 5%
	C	Low	High Torque	Medium	max. 6%
	D	Medium	Extra High Torque	Very Low	medium 7% - 11% high 12% - 17%
	F	Low	Low Torque	High	max. 6%

Applications:

A ...is a variation of **B** and having a higher locked rotor current.

B …use for blowers, fans, unloaded compressors, rotary pumps.

C …use for large blowers and centrifugal pumps.

D …use for cranes, hoists, jacking gear and oil well pumping jacks.

F …motor / generator sets

ENCLOSURE DEFINITIONS

FOR NEMA INDUCTION MOTORS

TEFC Totally Enclosed, Fan Cooled

The most commonly used motor in ordinary industrial environments; a small fan on the rear shaft of the motor, covered by housing, draws air over the motor fins to cool the motor. The motor is dust tight, and has a moderate water seal as well. TEFC motors are not secure against high pressure water.

ODP Open, Drip Proof

These motors are relatively inexpensive motors used in normal applications; care should be taken not to use the motor in applications where the TEFC motor is required.

TEAO Totally Enclosed, Air Over

This type of motor is designed to be used solely in the air stream of the fan or blower which they are driving.

TEBC Totally Enclosed, Blower Cooled

They are most commonly used for variable speed motors combined with variable speed drives. An independent blower pulls air over the motor fins to keep the motor cool at all operating speeds.

TENV Totally Enclosed, Not Ventilated

This motor has extra metal and extra fins to allow radiation of this heat and is built with special high temperature insulation. The motor is designed to run hot, care should be taken to avoid human contact with the body of the motor, as well as contact between inflammable objects and the motor.

TEWC Totally Enclosed, Water Cooled

The TEWC motor is most commonly used for submersible pumps.

EPNV Explosion Proof, No Ventilated

A special enclosed motor designed to withstand an internal explosion of specified gases or vapors, and not allow the internal flame or explosion to escape. Available as non-ventilated (EPNC) in smaller ratings below 1/3 HP. Explosion-proof motors are labeled to meet UL and NEC requirements.

EPFC Explosion Proof, Fan Cooled

A special enclosed motor designed to withstand an internal explosion of specified gases or vapors, and not allow the internal flame or explosion to escape. Fan-cooled (EPFC) in ratings above 1/3 HP. Explosion-proof motors are labeled to meet UL and NEC requirements.

TEXP Totally Enclosed Explosion Proof

An explosion proof motor is designed to operate safely by limiting surface temperature in flammable gas, vapour, or explosive dust environments. The external temperature of these motors never reaches the level required to ignite hazardous materials in the vicinity of operation. These atmospheres may contain anything from gases to dust particles in explosive quantities. Pay careful attention in precisely specifying a hazardous operating location. **TEXP** motors are available as **EPNV** motors and **EPFC** motors.

ENVIRONMENTAL PROTECTION

- **NEMA and CSA Enclosure Types**

  NEMA enclosure standards represent an enclosure's ability to protect against the external environment.

  Type 1 …not specifically identified in the CSA Standard

  Intended for indoor use primarily to provide a degree of protection against (hand) contact with the enclosed equipment. Sometimes known as a "finger-tight" enclosure. This is the least costly enclosure, but is suitable only for clean, dry environments.

  Type 2

  Intended for indoor use primarily to provide a degree of protection against limited amounts of falling dirt and water.

  Type 3

  Intended for outdoor use primarily to provide a degree of protection against windblown dust, rain, and sleet; undamaged by ice which forms on the enclosure.

  Type 3R

  Intended for outdoor use primarily to provide a degree of protection against falling rain and sleet; undamaged by ice which forms on the enclosure. This is the most common outdoors enclosure.

  Type 3S

  Intended for outdoor use primarily to provide a degree of protection against rain, sleet, windblown dust; and to provide for operation of external mechanisms when ice laden.

  Type 4

  Intended for indoor or outdoor use primarily to provide a degree of protection against windblown dust and rain, splashing water, and hose directed water; undamaged by ice which forms on the enclosure.

  Type 4X

  Intended for indoor or outdoor use primarily to provide a degree of protection against corrosion, windblown dust and rain, splashing water, and hose directed water; undamaged by ice which forms on the enclosure. This is the most common enclosure in "food" environments. Commonly made from stainless steel or fiberglass.

  Type 5

  Intended for indoor use primary to provide a degree of protection against settling airborne dust, falling dirt, and dripping non corrosive liquids.

Type 6
Intended for use indoors or outdoors to provide a degree of protection against hose directed water, the entry of water during occasional temporary submersion at a limited depth; and damages from external ice formation.

Type 6P
Intended for use indoors or outdoors to provide a degree of protection against hose-directed water, the entry of water during prolonged submersion at a limited depth; and damage from external ice formation. This type is recommended when extensive wash downs are performed.

Type 7 …this type is specific to the US only and not used by CSA.
Intended for use indoors use in locations classified as Class 1, Groups A, B, C or D.

Type 8 …this type is specific to the US only and not used by CSA.
Intended for use indoors or outdoor use in locations classified as Class 1, Groups A, B, C or D.

Type 9 …this type is specific to the US only and not used by CSA.
Intended for use indoors use in locations classified as Class 2, Groups E, F and G.

Type 10 …this type is specific to the US only and not used by CSA.
These enclosures are constructed to meet the applicable requirements of the Mine Safety and Health Administration.

Type 12
Intended for use indoors to provide a degree of protection against circulating dust, falling dirt, and dripping noncorrosive liquids. This is the most common type enclosure used in normal factory environments.

Type 13
Intended for use indoors to provide a degree of protection against circulating dust, falling dirt, and the dripping of water, oil, and noncorrosive coolant.

- **IEC Protection Classes Of Enclosures (IP CODE)**

The IEC uses the term “Ingress Protection” (IP) to identify the environmental protection of an enclosure. IP Codes are comparable to NEMA Enclosure Types. The IP classification system designates, by means of a number, the degree of protection provided by an enclosure and the electrical equipment against physical contact, foreign bodies and water ingress.

Digit	First Digit, Physical Protection	Foreign Body Protection	Second Digit, Water Protection
0	Non protected	Non protected	Non protected
1	Protection against back of hand contact	Protected against solid objects greater than 50mm (2 inch)	Protected against water dripping vertically
2	Protection against finger contact	Protected against solid objects greater than 12mm (1/2 inch)	Protected against vertically dripping water when tilted up to 15 deg.
3	Protection against contact from a wire or tools	Protected against solid objects greater than 2.5mm (0.1 inch)	Protected against spraying water at an angle up to 60 deg. From the vertical
4	Protection against contact with a wire or strip of thickness greater than 1mm (0.04 inch)	Protected against solid objects greater than 1mm (0.04 inch)	Protected against splashing water from any direction
5	Protected against contact with a wire	Dust protected prevents ingress of dust in sufficient quantity to interfere with operation of equipment	Protected against water jets from any direction
6	Protected against contact with a wire	Dust tight no dust ingress	Protected against heavy seas or powerful jets of water and prevents ingress sufficient to cause harm
7			Protected against the effects of immersion between a depth of 15cm and 1m
8			Protected against submersion, suitable for continuous immersion in water under conditions specified by the manufacture

- **NEMA Enclosure Types vs. IEC Classification Designation**

NEMA Enclosure Type Number	IEC Enclosure Classification
1	IP 10
2	IP 11
3	IP 54
3R	IP 14
3S	IP 54
4 and 4X	IP 56
5	IP 52
6 and 6P	IP 67
12 and 12K	IP 52
13	IP 54

POLES, RPM AND FREQUENCY

FOR THREE-PHASE INDUCTION MOTORS

Synchronous Speed					
POLES	60 Hz RPM	50 Hz RPM	POLES	60 Hz RPM	50 Hz RPM
2	3600.0	3000.0	12	600.0	500.0
4	1800.0	1500.0	16	450.0	375.0
6	1200.0	1000.0	20	360.0	300.0
8	900.0	750.0	24	300.0	250.0
10	720.0	600.0	32	225.0	187.5

Synchronous speed of an induction motor is the speed at which its magnetic field revolves. The synchronous speed is directly proportional to the frequency of the supply voltage and the number of poles per phase for which the stator is wound.

$$\text{SYNCHRONOUS SPEED} = \frac{\text{FREQUENCY X 120}}{\text{POLES}}$$

The slip of an induction motor is the ratio of the difference between synchronous speed and the actual rotor (shaft) speed.

$$\text{SLIP} = \text{SYNCHRONOUS SPEED} - \text{ROTOR SPEED}$$

$$\text{SLIP (\%)} = \frac{\text{SYNCHRONOUS SPEED} - \text{ROTOR SPEED}}{\text{SYNCHRONOUS SPEED}} \text{ X 100}$$

$$\text{ROTOR SPEED} = \text{SYNCHRONOUS SPEED} - \text{SLIP}$$

The rotor slips a certain number of revolutions behind the revolving magnetic field of the stator. The greater the load on the motor shaft, the more the rotor slips behind the synchronous speed of the revolving magnetic field. When there is no load on a motor the slip is very small and the rotor speed is nearly equal to the synchronous speed. The slip varies with the design of a motor and may vary from 2.0% to 7.5% at full load in motors of ordinary design, and up to 17% in high slip motors.

The slip of an induction motor varies directly proportional with the load. Doubling of the load will double the slip.

GENERAL EFFECT OF VOLTAGE AND FREQUENCY VARIATIONS

ON INDUCTION MOTORS CHARACTERISTICS

Characteristic	Voltage		Frequency	
	90 %	110 %	95 %	105 %
starting torque	19% down	21% up	11% up	10% down
maximum torque	19% down	21% up	11% up	10% down
percent slip	20 - 30% up	15 - 20% down	5 - 10% down	10 - 15% up
full load efficiency	0 - 2% down	0 - 3% down	slightly down	slightly up
3/4 load efficiency	little change	slightly down	slightly down	slightly up
1/2 load efficiency	0 - 1% up	5 - 10% down	slightly down	slightly up
power factor at full load	1 - 7% up	5 - 15% down	slightly down	slightly up
power factor at 3/4 load	2 - 7% up	5 - 15% down	slightly down	slightly up
power factor at 1/2 load	3 - 10% up	10 - 20% down	slightly down	slightly up
full load current	5 - 10% up	slightly down to 5% up	slightly up	slightly down
starting current	10% down	10% up	5% up	5% down
full load temperature rise	10 - 15% down	10% up	slightly up	slightly down
maximum overload capacity	19% down	21% up	slightly up	slightly down
magnetic noise	slightly down	slightly up	slightly up	slightly down

COMPARISON OF METHODS OF STARTING

SQUIRREL CAGE INDUCTION MOTORS

Starter Type	Percent of Full Voltage Value		
	Voltage At Motor	Line Current	Motor Outp. Torque
full voltage	100 %	100 %	100 %
autotransformer 80% tap	80%	64%	64%
autotransformer 65% tap	65%	42%	42%
autotransformer 50% tap	50%	25%	25%
primary reactor 80% tap	80%	80%	64%
primary reactor 65% tap	65%	65%	42%
primary reactor 50% tap	50%	50%	25%
primary resistor, typical rating	80%	80%	64%
part winding at low speed motors (1/2-1/2)	100 %	50%	50%
part winding at high speed motors (1/2-1/2)	100 %	70%	50%
part winding at high speed motors (2/3-1/3)	100 %	65%	42%
wye start / delta run (1/3-1/3)	100 %	33%	33%

FULL LOAD EFFICIENCIES

OF ENERGY EFFICIENT INDUCTION MOTORS

Hp	OPEN MOTORS						ENCLOSED MOTORS					
	2 Pole		4 Pole		6 Pole		2 Pole		4 Pole		6 Pole	
	Nom	Min	Nom	Min	Nom	Min	Nom	Min	Nom	Min	Nom	Min
1			82.5%	81.5%	80.0%	78.5%	75.5%	74.0%	82.5%	81.5%	80.0%	78.5%
1 1/2	82.5%	81.5%	84.0%	82.5%	84.0%	82.5%	82.5%	81.5%	84.0%	82.5%	85.5%	84.0%
2	84.0%	82.5%	84.0%	82.5%	85.5%	84.0%	84.0%	82.5%	84.0%	82.5%	86.5%	85.5%
3	84.0%	82.5%	86.5%	85.5%	86.5%	85.5%	85.5%	84.0%	87.5%	86.5%	87.5%	86.5%
5	85.5%	84.0%	87.5%	86.5%	87.5%	86.5%	87.5%	86.5%	87.5%	86.5%	87.5%	86.5%
7 1/2	87.5%	86.5%	88.5%	87.5%	88.5%	87.5%	88.5%	87.5%	89.5%	88.5%	89.5%	88.5%
10	88.5%	87.5%	89.5%	88.5%	90.2%	89.5%	89.5%	88.5%	89.5%	88.5%	89.5%	88.5%
15	89.5%	88.5%	91.0%	90.2%	90.2%	89.5%	90.2%	89.5%	91.0%	90.2%	90.2%	89.5%
20	90.2%	89.5%	91.0%	90.2%	91.0%	90.2%	90.2%	89.5%	91.0%	90.2%	90.2%	89.5%
25	91.0%	90.2%	91.7%	91.0%	91.7%	91.0%	91.0%	90.2%	92.4%	91.7%	91.7%	91.0%
30	91.0%	90.2%	92.4%	91.7%	92.4%	91.7%	91.0%	90.2%	92.4%	91.7%	91.7%	91.0%
40	91.7%	91.0%	93.0%	92.4%	93.0%	92.4%	91.7%	91.0%	93.0%	92.4%	93.0%	92.4%
50	92.4%	91.7%	93.0%	92.4%	93.0%	92.4%	92.4%	91.7%	93.0%	92.4%	93.0%	92.4%
60	93.0%	92.4%	93.6%	93.0%	93.6%	93.0%	93.0%	92.4%	93.6%	93.0%	93.6%	93.0%
75	93.0%	92.4%	94.1%	93.6%	93.6%	93.0%	93.0%	92.4%	94.1%	93.6%	93.6%	93.0%
100	93.0%	92.4%	94.1%	93.6%	94.1%	93.6%	93.6%	93.0%	94.5%	94.1%	94.1%	93.6%
125	93.6%	93.0%	94.5%	94.1%	94.1%	93.6%	94.5%	94.1%	94.5%	94.1%	94.1%	93.6%
150	93.6%	93.0%	95.0%	94.5%	94.5%	94.1%	94.5%	94.1%	95.0%	94.5%	95.0%	94.5%
200	94.5%	94.1%	95.0%	94.5%	94.5%	94.1%	95.0%	94.5%	95.0%	94.5%	95.0%	94.5%

POWER FACTORS

OF THREE PHASE SQUIRREL CAGE INDUCTION MOTORS

Hp	1/2 Load	3/4 Load	Full Load
1	57.0	69.0	76.0
1 1/2	64.0	76.0	81.0
2	68.0	79.0	84.0
3	70.0	80.0	84.0
5	76.0	83.0	86.0
7 1/2	77.0	84.0	87.0
10	77.0	86.0	88.0
15	81.0	85.0	87.0
20	82.0	86.0	87.0
25	82.0	86.0	87.0
30	83.0	86.5	87.0
40	84.0	87.0	88.0
50	84.0	87.0	88.0
60	84.0	87.0	88.0
75	84.0	87.0	88.0
100	84.0	88.0	88.0
125	84.0	88.0	89.0
150	84.0	88.0	89.0
200	85.0	89.0	90.0

MOTOR TROUBLE SHOOTING CHART

Problem	Cause	What to do
Motor fails to start	Blown fuses	Replace fuses with proper type and rating
	Overload trips	Check and reset overload in starter
	Improper power supply	Check to see that supplied power agrees with motor rating plate and load factor
	Improper line connections	Check connections with diagram supplied with motor
	Open circuit or control switch	Indicated by humming sound when switch is closed, check for loose wiring connections, ensure that all control contacts are closed
	Machanical failure	Check to see if motor and drive turn freely, check bearings and lubrication.
	Short circuited stator	Indicated by blown fuses, motor must be rewound.
	Poor stator coil connection	Remove end bells, locate with test lamp
	Rotor defective	Look for broken bars or end rings
	Motor overloaded	Reduce load
Motor stalls	One phase may be open	Check lines for open phase
	Wrong application	Change type or size
	Overload	Reduce load
	Low voltage	Ensure the name plate voltage is maintained, check all connections
	Open circuit	Fuses blown, check overload relay, stator and push buttons
Motor runs and then dies down	Power failure	Check for loose wiring connections, fuses and control connections
Motor does not come up to speed	Voltage to low at motor terminals because of line drop	Use higher voltage or transformer terminals or reduce load, check connections, check supply cable for proper size.
	Starting load too high	Check load motor is supposed to carry at start
	Broken rotor bars or loose rotor	Look for cracks near the rings
	Open primary circuit	Locate fault with testing device
Motor takes too long to accelerate or draws high current	Excessive load	Reduce load
	Low voltage during start	Check for adequate wire size
	Defective squirrel cage rotor	replace rotor
Wrong rotation	Wrong sequence of phases	Reverse connections at motor or at switchboard
Motor overheats while running underloaded	Frame or bracket vents may be clogged with dirt and prevent proper ventilation of motor	Open vent holes and check for a continuous stream of air to the motor housing
	Motor may have one phase open	Check to make sure that all leads are connected
	Grounded coil	Locate and repair
	Unbalanced terminal voltage	Check for faulty and/or overheating leads, connections and terminals
Motor vibrates	Motor misaligned	Realign
	Weak support	Strengthen base
	Coupling out of balance	Balance coupling
	Driven equipment unbalanced	Rebalance driven equipment
	Defective bearings	Replace bearings
	Bearings not in line	Line up properly
	Balancing weights shifted	Rebalance motor
	Excessive end play	Adjust bearing or add shim
Scraping noise	Fan rubbing fan cover	Remove interference
	Fan striking insulation	Clear fan
	Motor loose on bedplate	Tighten holding bolts
Hot bearings	Excessive belt pull	Decrease belt tension
	Pulleys to far away	Move pulley closer to the bearing housing
	Pulley diameter to small	Use larger pulleys
	Misalignment	Realign
	Insufficient grease	Maintain proper quality of grease in bearing
	Deterioration of grease or lubricant contaminated	Remove old grease, wash bearings thoroughly and replace with new grease
	Excess lubricant	Reduce quantity of grease, a bearing should not be more than 1/2 filled
	Overloaded bearing	Check alignment, side and end thrust
	Broken ball or rough races	Replace bearing

GENERAL INSTRUCTIONS

- **Storage**
  A motor should always be stored indoors, in dry, vibration free and dust free conditions. Unprotected machined surfaces (shaft-ends and flanges) should be protected with anti-corrosive paint or grease. It is recommended that shafts be rotated periodically by hand to prevent grease migration.

- **Mechanical installation**
  …always use correct lifting facilities
  …the eyebolts are to support the motor only
  …eyebolts are designed for vertical lifting only
  …ensure a level mounting surface
  …ensure correct fasten torques
  …ensure gaskets, seals and guards correctly fitted
  …ensure adequate ventilation and space for maintenance

- **Electrical installation**
  …before working on a machine, ensure that it is switched off, and the power source is isolated
  …check insulation resistance of all windings with 500 V DC megger, if less than 10 MR dry out
  …the most important part of any motor is the name plate, check the data given on the name plate before making the connection
  …check overload setting
  …mains cables must be correctly sized
  …check terminal arrangements, tight connections
  …to change rotation of direction of three phase motor, swap to incoming phases
  …terminal box lids must be fitted after connection and testing
  …check motor is earthed

- **Maintenance and spare parts**
  …remember to isolate power source before any maintenance
  …periodic maintenance should be done every three month, check for visible damage, such as cracked fans, covers, feet, frames etc.
  …clean free of dust, dirt, fibres etc, from motor frame and fan cover
  …secure fasteners, cables and earth leads
  …never hammer a bearing, always use an extractor
  …avoid damaging windings when removing the rotor

FULL-LOAD CURRENTS AND CABLE SIZES

FOR NEMA THREE-PHASE INDUCTION MOTORS AT 60Hz

HP	230V	cable
1/2	2.0 A	AWG 18
3/4	2.8 A	AWG 18
1	3.6 A	AWG 18
1-1/2	5.2 A	AWG 18
2	6.8 A	AWG 18
3	9.6 A	AWG 18
5	15.2 A	AWG 16
7-1/2	22.0 A	AWG 14
10	28.0 A	AWG 12
15	42.0 A	AWG 10
20	54.0 A	AWG 8
25	68.0 A	AWG 6
30	80.0 A	AWG 4
40	104.0 A	AWG 3
50	130.0 A	AWG 2
60	154.0 A	AWG 1/0
75	192.0 A	AWG 2/0
100	248.0 A	AWG 4/0
125	312.0 A	kcmil 300
150	360.0 A	kcmil 400
200	480.0 A	kcmil 700

HP	460V	cable
1/2	1.0 A	AWG 18
3/4	1.4 A	AWG 18
1	1.8 A	AWG 18
1-1/2	2.6 A	AWG 18
2	3.4 A	AWG 18
3	4.8 A	AWG 18
5	7.6 A	AWG 18
7-1/2	11.0 A	AWG 18
10	14.0 A	AWG 16
15	21.0 A	AWG 14
20	27.0 A	AWG 12
25	34.0 A	AWG 10
30	40.0 A	AWG 10
40	52.0 A	AWG 8
50	65.0 A	AWG 6
60	77.0 A	AWG 4
75	96.0 A	AWG 3
100	124.0 A	AWG 2
125	156.0 A	AWG 1/0
150	180.0 A	AWG 2/0
200	240.0 A	AWG 4/0

HP	230V	cable
1/2	2.0 A	1.0 mm²
3/4	2.8 A	1.0 mm²
1	3.6 A	1.0 mm²
1-1/2	5.2 A	1.0 mm²
2	6.8 A	1.0 mm²
3	9.6 A	1.0 mm²
5	15.2 A	1.5 mm²
7-1/2	22.0 A	2.5 mm²
10	28.0 A	4.0 mm²
15	42.0 A	6.0 mm²
20	54.0 A	10.0 mm²
25	68.0 A	16.0 mm²
30	80.0 A	25.0 mm²
40	104.0 A	35.0 mm²
50	130.0 A	35.0 mm²
60	154.0 A	50.0 mm²
75	192.0 A	70.0 mm²
100	248.0 A	120.0 mm²
125	312.0 A	150.0 mm²
150	360.0 A	240.0 mm²
200	480.0 A	400.0 mm²

HP	460V	cable
1/2	1.0 A	1.0 mm²
3/4	1.4 A	1.0 mm²
1	1.8 A	1.0 mm²
1-1/2	2.6 A	1.0 mm²
2	3.4 A	1.0 mm²
3	4.8 A	1.0 mm²
5	7.6 A	1.0 mm²
7-1/2	11.0 A	1.0 mm²
10	14.0 A	1.5 mm²
15	21.0 A	2.5 mm²
20	27.0 A	4.0 mm²
25	34.0 A	6.0 mm²
30	40.0 A	6.0 mm²
40	52.0 A	10.0 mm²
50	65.0 A	16.0 mm²
60	77.0 A	25.0 mm²
75	96.0 A	35.0 mm²
100	124.0 A	35.0 mm²
125	156.0 A	50.0 mm²
150	180.0 A	70.0 mm²
200	240.0 A	120 mm²

...based on ambient air temperature of 86°F (30°C) and temperature rating of conductor 194°F (90°C).

(mm² = square-millimeter kcmil = kilo circular mils AWG = american wire gauge)

CABLE SIZE COMPARISON LIST

mm²	k MCM	AWG
0,00049	0,0010	50
0,00062	0,0012	49
0,00078	0,0015	48
0,00099	0,0020	47
0,00124	0,0024	46
0,00157	0,0031	45
0,00198	0,0039	44
0,00250	0,0049	43
0,00315	0,0062	42
0,00397	0,0078	41
0,00501	0,0099	40
0,00632	0,0125	39
0,00801	0,0158	38
0,01003	0,020	37
0,01267	0,025	36
0,01606	0,032	35
0,02011	0,040	34
0,02545	0,050	33
0,03205	0,063	32
0,04047	0,080	31
0,05067	0,100	30
0,06424	0,127	29
0,08093	0,160	28
0,10235	0,202	27
0,12882	0,254	26
0,16260	0,321	25
0,20508	0,405	24
0,25	0,493	
0,25787	0,509	23
0,32573	0,643	22
0,41055	0,810	21
0,5	0,987	
0,51785	1,02	20
0,65325	1,29	19
0,75	1,48	
0,82100	1,62	18
1	1,97	
1,31000	2,59	16
1,5	2,96	
2,08000	4,10	14
2,5	4,93	
3,31000	6,53	12
4	7,89	
5,26000	10,38	10
6	11,84	
8,36000	16,50	8
10	19,73	

mm²	k MCM	AWG
13,3	26,24	6
16	31,57	
21,1	41,64	4
25	49,33	
26,7	52,68	3
33,6	66,30	2
35	69,06	
42,4	83,66	1
50	98,66	
53,5	106	1/0
53,5	106	0
67,4	133	2/0
67,4	133	00
70	138	
85	168	3/0
85	168	000
95	188	
107	212	4/0
107	212	0000
120	237	
127	250	
150	296	
151	300	
159	313	
177	350	
185	365	
203	400	
225	444	
240	474	
253	500	
271	535	
279	550	
300	592	
304	600	
355	700	
380	750	
394	777	
400	789	
406	800	
456	900	
500	986	
507	1000	
625	1233	
634	1250	
761	1500	
887	1750	
1014	2000	

(mm² = square-millimeter kcmil = kilo circular mils AWG = american wire gauge)

COMMON FRACTIONS OF AN INCH

DECIMAL AND METRIC EQUIVALENTS

inch		mm	inch		mm	inch		mm
1/128	0.008	0.198	11/32	0.344	8.731	87/128	0.680	17.264
1/64	0.016	0.397	45/128	0.352	8.930	11/16	0.688	17.463
3/128	0.023	0.595	23/64	0.359	9.128	89/128	0.695	17.661
1/32	0.031	0.794	47/128	0.367	9.327	45/64	0.703	17.859
5/128	0.039	0.992	3/8	0.375	9.525	91/128	0.711	18.058
3/64	0.047	1.191	49/128	0.383	9.723	23/32	0.719	18.256
7/128	0.055	1.389	25/64	0.391	9.922	93/128	0.727	18.455
1/16	0.063	1.588	51/128	0.398	10.120	47/64	0.734	18.653
9/128	0.070	1.786	13/32	0.406	10.319	95/128	0.742	18.852
5/64	0.078	1.984	53/128	0.414	10.517	3/4	0.750	19.050
11/128	0.086	2.183	27/64	0.422	10.716	97/128	0.758	19.248
3/32	0.094	2.381	55/128	0.430	10.914	49/64	0.766	19.447
13/128	0.102	2.580	7/16	0.438	11.113	99/128	0.773	19.645
7/64	0.109	2.778	57/128	0.445	11.311	25/32	0.781	19.844
15/128	0.117	2.977	29/64	0.453	11.509	101/128	0.789	20.042
1/8	0.125	3.175	59/128	0.461	11.708	51/64	0.797	20.241
17/128	0.133	3.373	15/32	0.469	11.906	103/128	0.805	20.439
9/64	0.141	3.572	61/128	0.477	12.105	13/16	0.813	20.638
19/128	0.148	3.770	31/64	0.484	12.303	105/128	0.820	20.836
5/32	0.156	3.969	63/128	0.492	12.502	53/64	0.828	21.034
21/128	0.164	4.167	1/2	0.500	12.700	107/128	0.836	21.233
11/64	0.172	4.366	65/128	0.508	12.898	27/32	0.844	21.431
23/128	0.180	4.564	33/64	0.516	13.097	109/128	0.852	21.630
3/16	0.188	4.763	67/128	0.523	13.295	55/64	0.859	21.828
25/128	0.195	4.961	17/32	0.531	13.494	111/128	0.867	22.027
13/64	0.203	5.159	69/128	0.539	13.692	7/8	0.875	22.225
27/128	0.211	5.358	35/64	0.547	13.891	113/128	0.883	22.423
7/32	0.219	5.556	71/128	0.555	14.089	57/64	0.891	22.622
29/128	0.227	5.755	9/16	0.563	14.288	115/128	0.898	22.820
15/64	0.234	5.953	73/128	0.570	14.486	29/32	0.906	23.019
31/128	0.242	6.152	37/64	0.578	14.684	117/128	0.914	23.217
1/4	0.250	6.350	75/128	0.586	14.883	59/64	0.922	23.416
33/128	0.258	6.548	19/32	0.594	15.081	119/128	0.930	23.614
17/64	0.266	6.747	77/128	0.602	15.280	15/16	0.938	23.813
35/128	0.273	6.945	39/64	0.609	15.478	121/128	0.945	24.011
9/32	0.281	7.144	79/128	0.617	15.677	61/64	0.953	24.209
37/128	0.289	7.342	5/8	0.625	15.875	123/128	0.961	24.408
19/64	0.297	7.541	81/128	0.633	16.073	31/32	0.969	24.606
39/128	0.305	7.739	41/64	0.641	16.272	125/128	0.977	24.805
5/16	0.313	7.938	83/128	0.648	16.470	63/64	0.984	25.003
41/128	0.320	8.136	21/32	0.656	16.669	127/128	0.992	25.202
21/64	0.328	8.334	85/128	0.664	16.867	1	1.000	25.400
43/128	0.336	8.533	43/64	0.672	17.066			

MAXIMUM HORSEPOWER FOR NEMA MOTOR STARTERS

NEMA motor starters refer to a standardized rating system for the electrical performance of the most common style of American-built motor starters, and they are rated by size: 00, 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9. Unlike IEC starters, most NEMA starters use heater-based overload relays.

NEMA	Full Voltage Starting			Auto Transformer Starting			Part Winding Starting			Wye Delta Starting		
SIZE	200V	230V	460/575V	200V	230V	460/575V	200V	230V	460/575V	200V	230V	460/575V
00	1 1/2	1 1/2	2									
0	3	3	5									
1	7 1/2	7 1/2	10	7 1/2	7 1/2	10	10	10	15	10	10	15
2	10	15	25	10	15	25	20	25	40	20	25	40
3	25	30	50	25	30	50	40	50	75	40	50	75
4	40	50	100	40	50	100	75	75	150	60	75	150
5	75	100	200	75	100	200	150	150	350	150	150	300
6	150	200	400	150	200	400		300	600	300	350	700
7		300	600		300	600		450	900	500	500	1000
8		450	900		450	900		700	1400	750	800	1500
9		800	1600		800	1600		1300	2600	1500	1500	3000

IEC MOTOR STARTERS

IEC starters are rated by current in one of several manners:

Thermal Current : The current which a contactor can withstand without becoming overheated.

Operational Current : The capability of the contactor to make and break current under different utilization Categories (AC-1, AC-2, AC-3, AC-4).

Select the utilization category which best represents your load and manner of usage. Then check the starter Max I_e list to select the appropriate starter.

AC-1 : …non-inductive or slightly inductive loads (resistive loads) such as resistance furnaces.

AC-2 : …slip-ring motors, starting, plugging (stopping or reversing the motor while running).

AC-3 : …squirrel cage (AC Induction) motors, starting, switching off motor while running.
…this is the most commonly used starter category.

AC-4 : …squirrel cage (AC Induction) motors, plugging, jogging, inching.

Max I_e	kW (50 Hz)				HP (60 Hz)			
(Ampere)	220 VAC	380 VAC	500 VAC	660 VAC	200 VAC	230 VAC	460 VAC	575 VAC
9	2.2	4	5.5	5.5	2	2	5	7 1/2
12	3	5.5	7.5	7.5	3	3	7 1/2	10
18	4	7.5	11	11	5	5	10	15
24	5.5	11	15	15	5	7 1/2	15	20
30	7.5	15	18.5	18.5	7 1/2	10	20	25
38	10	18.5	22	18.5	10	10	25	30
45	11	22	30	22	10	15	30	40
60	15	30	37	37	15	20	40	50
75	22	37	45	45	20	25	50	60
110	30	55	75	75	30	40	75	100
180	45	90	110	110	60	60	150	150
250	75	132	160	160	75	100	200	250
304	90	160	200	200	100	100	250	300
414	120	220	280	280	125	150	350	400
608	180	315	445	445	200	250	500	600

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Bad Bentheim 3rd. November 2004
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