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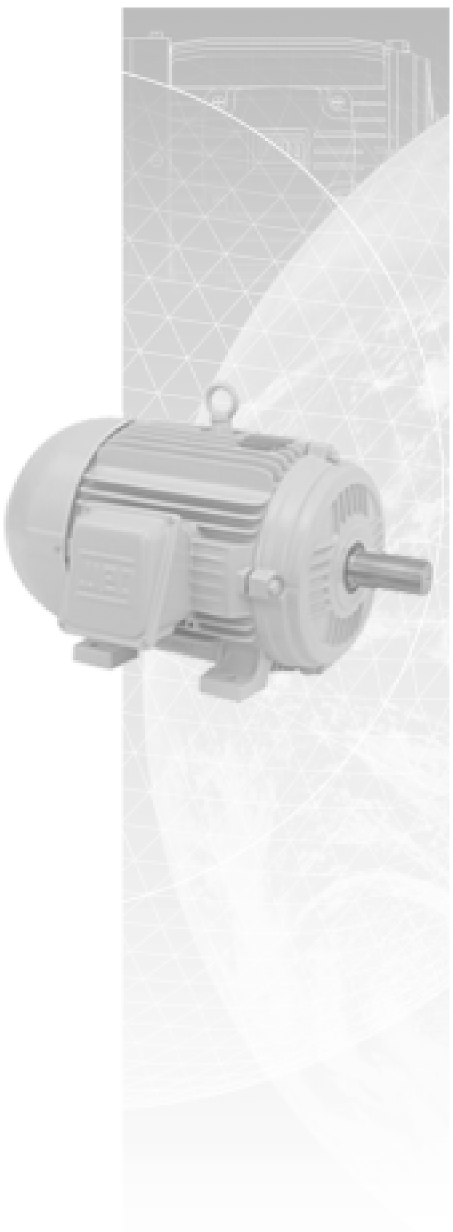
INSTALLATION AND MAINTENANCE MANUAL FOR NEMA LOW VOLTAGE ELECTRIC MOTORS



The electric motor is the item of equipment most widely used by man in his pursuit of progress, as virtually all machines and many renowned inventions depend upon it.
By virtue of the prominent role the electric motor plays in the comfort and welfare of mankind, it must be regarded and treated as a prime power unit embodying features that merit special attention, including its installation and maintenance.
This means that the electric motor should receive proper attention.
Its installation and routine maintenance require specific care to ensure perfect operation and longer life of the unit.
THE WEG ELECTRIC MOTOR INSTALLATION AND MAINTENANCE MANUAL provides the necessary information to properly install, maintain and preserve the most important component of all equipment:

THE ELECTRIC MOTOR!

WEG

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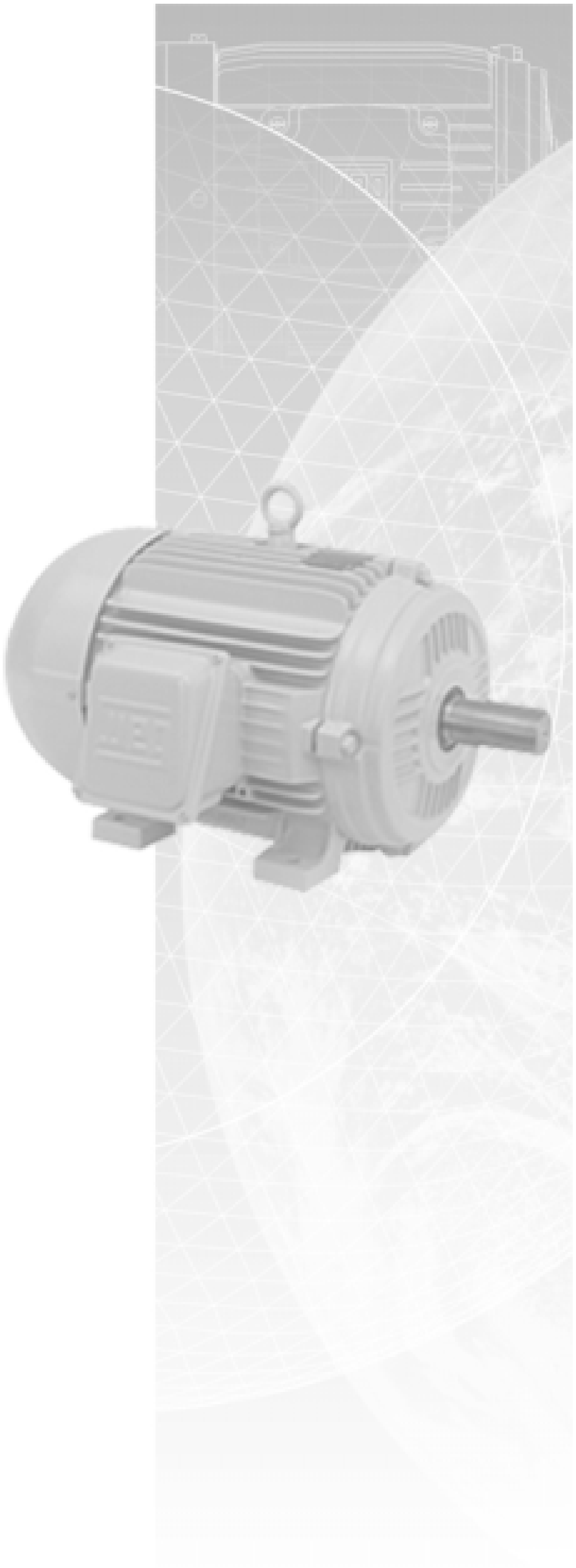
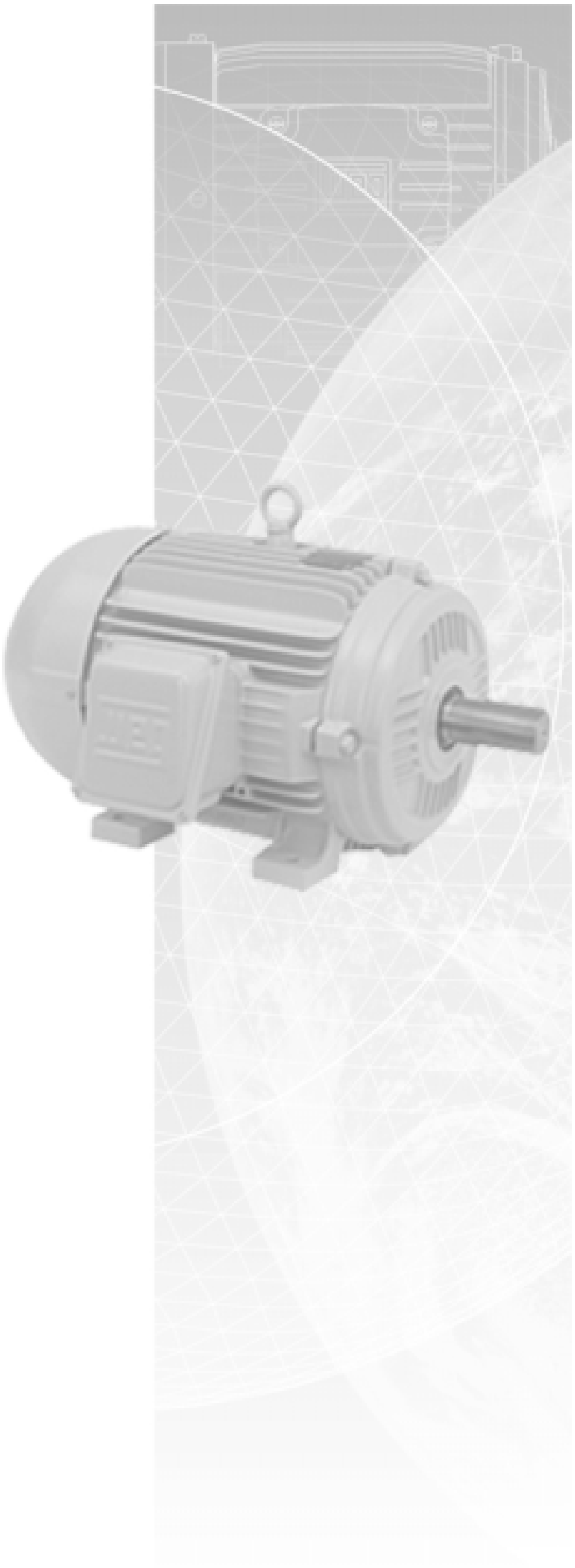


1. Introduction



This manual covers all the three-phase and single-phase asynchronous squirrel-cage induction motors, from 140T to 580T frame sizes.

The motors described in this manual are subject to continuous improvement and all information is subject to change without notice.
For further details, please consult WEG.

2. Basic Instructions

2.1 Safety Instructions

All personnel involved with electrical installations, either handling, lifting, operation and maintenance, should be well-informed and up-to-date concerning the safety standards and principles that govern the work and carefully follow them.
Before work commences, it is the responsibility of the person in charge to ascertain that these have been duly complied with and to alert his personnel of the inherent hazards of the job in hand.
It is recommended that these tasks be undertaken only by qualified personnel and they should be instructed to:

· avoid contact with energized circuits or rotating parts,
· avoid by-passing or rendering inoperative any safeguards or protective devices,
· avoid extended exposure in close proximity to machinery with high noise levels,
· use proper care and procedures in handling, lifting, installing, operating and maintaining the equipment, and
· follow consistently any instructions and product documentation supplied when they do such work.

Before initiating maintenance procedures, be sure that all power sources are disconnected from the motor and accessories to avoid electric shock.
Fire fighting equipment and notices concerning first aid should not be lacking at the job site; these should be visible and accessible at all times.

2.2 Delivery

Prior to shipment, motors are factory-tested and balanced. They are packed in boxes or bolted to a wooden base.
Upon receipt, we recommend careful handling and a physical examination for damage which may have occurred during transportation.
In the event of damage and in order to guaranty insurance coverage, both the nearest WEG sales office and the carrier should be notified without delay.

2.3 Storage

Motors should be raised by their eyebolts and never by their shafts. It is important that high rating three-phase motors be raised by their eyebolts. Raising and lowering must be steady and joltless, otherwise bearings may be harmed.
When motors are not immediately installed, they should be stored in their normal upright position in a dry even temperature place, free of dust, gases and corrosive atmosphere.
Other objects should not be placed on or against them.
Motors stored over long periods are subject to loss of insulation resistance and oxidation of bearings.

Bearings and lubricant deserve special attention during prolonged periods of storage. Depending on the length and conditions of storage it may be necessary to regrease or change rusted bearings. The weight of the rotor in an inactive motor tends to expel grease from between the bearing surfaces thereby removing the protective film that impedes metal-to-metal contact.
As a preventive measure against the formation of corrosion by contact, motors should not be stored near machines which cause vibrations, and every 3 month their shafts should be rotated manually.

Insulation resistance fluctuates widely with temperature and humidity variations and the cleanliness of components. When a motor is not immediately put into service it should be protected against moist, high temperatures and impurities, thus avoiding damage to insulation resistance.
If the motor has been in storage more than six month or has been subjected to adverse moisture conditions, it is best to check the insulation resistance of the stator winding with a megohmeter.
If the resistance is lower than ten megohms the windings should be dried in one of the two following ways:

1) Bake in oven at temperatures not exceeding 194 degrees F until insulation resistance becomes constant.
2) With rotor locked, apply low voltage and gradually increase current through windings until temperature measured with thermometer reaches 194 degrees F. Do not exceed this temperature.

If the motor is stored for an extensive period, the rotor must be periodically rotated.
Should the ambient conditions be very humid, a periodical inspection is recommended during storage. It is difficult to prescribe rules for the true insulation resistance value of a machine as resistance varies according to the type, size and rated voltage and the state of the insulation material used, method of construction and the machine's insulation antecedents. A lot of experience is necessary in order to decide when a machine is ready or not to be put into service. Periodical records are useful in making this decision.

The following guidelines show the approximate values that can be expected of a clean and dry motor, at 40°C test voltage in applied during one minute.

Insulation resistance Rm is obtained by the formula:

$$Rm = Vn + 1$$

Where: Rm - minimum recommended insulation resistance in MΩ with winding at 40°C
Vn - rated machine voltage in kV

In case the test is carried out at a temperature other than 40°C, the value must be corrected to 40°C using an approximated curve of insulation resistance v.s temperature of the winding with the aid of Figure 2.1; it's possible verify that resistance practically doubles every 10°C that insulating temperature is lowered.

Example:

Ambient temperature = 50°C
Motor winding resistence at 50°C = 1.02 MΩ
Correction to 40°C

$$R_{40°C} = R_{50°C} \times K_{50°C}$$
$$R_{40°C} = 1.02 \times 1.3$$
$$R_{40°C} = 1.326\ M\Omega$$

The minimum resistence Rm will be:

$$Rm = Vn + 1$$
$$Rm = 0.440 + 1$$
$$Rm = 1.440\ M\Omega$$

On new motors, lower values are often attained due to solvents present in the insulating varnishes that later evaporate during normal operation. This does not necessarily mean that the motor is not operational, since insulating resistance will increase after a period of service.
On motors which have been in service for a period of time much larger values are often attained. A comparison of the values recorded in previous tests on the same motor under similar load, temperature and humidity conditions, serves as a better indication of insulation condition than that of the value derived from a single test. Any substantial or sudden reduction is suspect and the cause determined and corrective action taken.
Insulation resistance is usually measured with a MEGGER.
In the event that insulation resistance is inferior to the values derived from the above formula, motors should be subjected to a drying process.

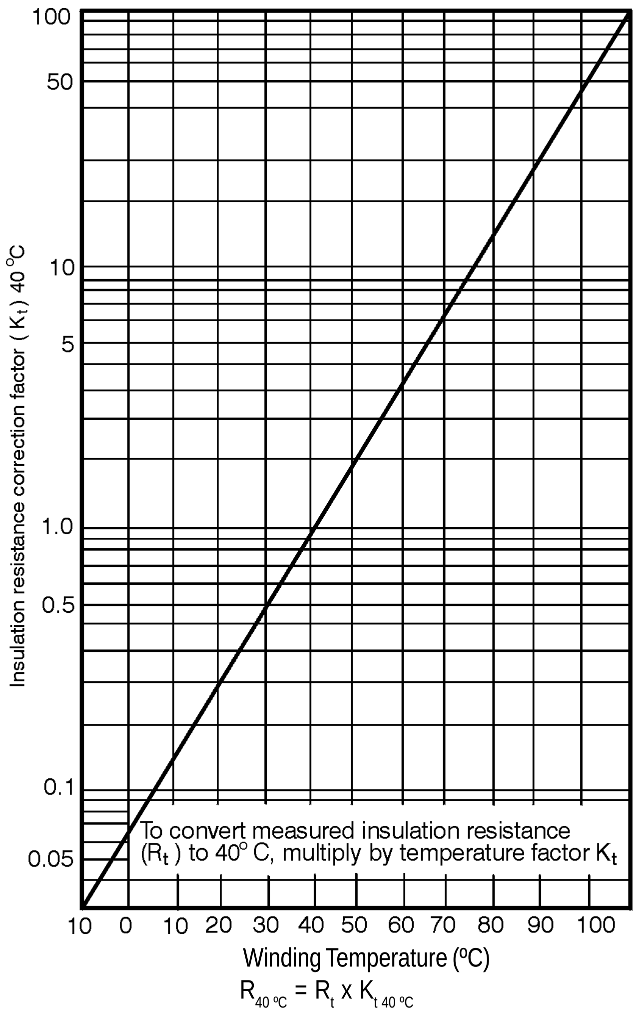


Figure 2.1

2.3.1 Drying the windings

This operation should be carried out with maximum care, and only by qualified personnel. The rate of temperature rise should not exceed 5°C per hour and the temperature of the winding should not exceed 105°C. An overly high final temperature as well as a fast temperature increase rate can each generate vapour harmful to the insulation.
Temperature should be accurately controlled during the drying process and the insulation resistance measured at regular intervals.
During the early stages of the drying process, insulation resistance will decrease as a result of the temperature increase, but the resistance will increase again when the insulation becomes dryer.
The drying process should be extended until sucessive measurements of insulation resistance indicate that a constant value above the minimum acceptable value has been attained. It is extremely important that the interior of the motor be well ventilated during the drying operation to ensure that the dampness is really removed.
Heat for drying can be obtained from outside sources (an oven), energization of the space heater (optional), or introducing a current through the actual winding of the motor being dried.

3. Installation

Electric machines should be installed in order to allow an easy access for inspection and maintenance. Should the surrounding atmosphere be humid, corrosive or contain flammable substances or particles, it is essential to ensure an adequate degree of protection.
The installation of motors in environments where there are vapours, gases or dusts, flammable or combustible materials, subject to fire or explosion, should be undertaken according to appropriate and governing codes, such as NEC Art. 500 (National Electrical Code) and UL-674 (Underwriters Laboratories, Inc.) Standards.
Under no circumstances can motors be enclosed in boxes or covered with materials which may impede or reduce the free circulation of ventilating air. Machines fitted with external ventilation should be at least 50cm from the wall to permit the passage of air.
The opening for the entry and exit of air flow should never be obstructed or reduced by conductors, pipes or other objects.
The place of installation should allow for air renewal at a rate of 700 cubic feet per minute for each 75 HP motor capacity.

3.1 Mechanical Aspects

3.1.1 Foundation

The motor base must be levelled and as far as possible free of vibrations. A concrete foundation is recommended for motors over 100 HP. The choice of base will depend upon the nature of the soil at the place of erection or of the floor capacity in the case of buildings.
When dimensioning the motor base, keep in mind that the motor may occasionally be run at a torque above that of the rated full load torque. Based upon Figure 3.1, foundation stresses can be calculated by using the following formula:

$$F1 = 0.2247 (0.009 \times g \times G - 213 \; Tmáx/A)$$

$$F2 = 0.2247 (0.009 \times g \times G + 213 \; Tmax/A)$$

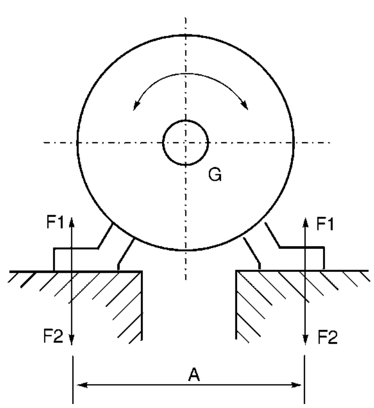


Figure 3.1 - Base stresses

Where:

F1 and F2 - Lateral stress (Lb)
g - Force of gravity (32.18 ft/s^2)
G - Weight of motor (Lb)
Tmax - Maximum torque (Lb . Ft)
A - Obtained from the dimensional drawing of the motor (in)

Sunken bolts or metallic base plates should be used to secure the motor to the base.

3.1.2 Types of Bases

a) Slide Rails

When motor drive is by pulleys the motor should be mounted on slide rails and the lower part of the belt should be pulling.
The rail nearest the drive pulley is positioned in such a manner that the adjusting bolt be between the motor and the driven machine.
The other rail should be positioned with the bolt in the opposite position, as shown in Figure 3.2.
The motor is bolted to the rails and set on the base. The drive pulley is aligned such that its center is on a plane with the center of the driven pulley and the motor shaft and that of the machine be parallel.

The belt should not be overly stretched, see Figure 3.11.
After the alignment, the rails are fixed.

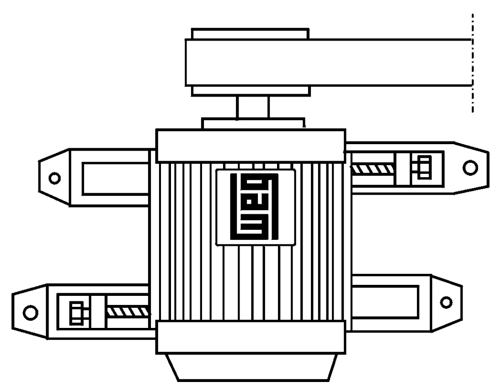


Figure 3.2 - Positioning of slide rails for motor alignment

b) Foundation Studs

Very often, particularly when drive is by flexible coupling the motor is anchored directly to the base with foundation studs.
It is recommended that shim plates of approximately 0.8 inches be used between the foundation studs and the feet of the motor for replacement purposes. These shim plates are useful when exchanging one motor for another of larger shaft height due to variations allowed by standard tolerances.
Foundation studs should neither be painted nor rusted as both interfere with to the adherence of the concrete, and bring about loosening.
After accurate alignment and levelling of the motor, the foundation studs are cemented and their screws tightened to secure the motor.

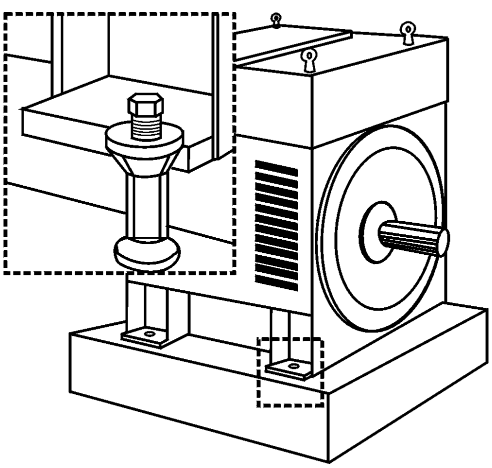


Figure 3.3 - Motor mounted on a concrete base with foundation studs

3.1.3 Alignment

The electric motor should be accurately aligned with the driven machine, particularly in cases of direct coupling. An incorrect alignment can cause bearing failure vibrations and even shaft rupture.
The best way to ensure correct alignment is to use dial gauges placed on each coupling half, one reading radially and the other exially - Figure 3.5.

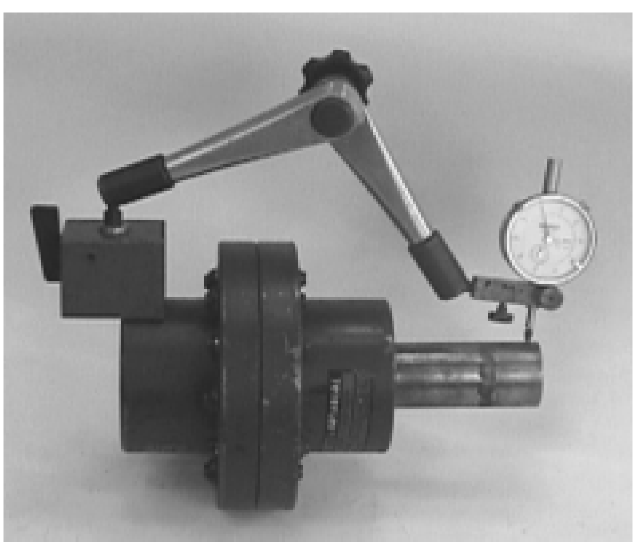


Figure 3.5 - Alignment with dial gauges

Thus, simultaneous readings are possible and allow for checking for any parallel (Figure 3.6a) and concentricity deviations (Figure 3.6b) by rotating the shafts one turn.
Gauge readings should not exceed 0.02 inches. If the installer is sufficiently skilled, he can obtain alignment with feeler gauges and a steel ruler, providing that the couplings are perfect and centered - Figure 3.6c.

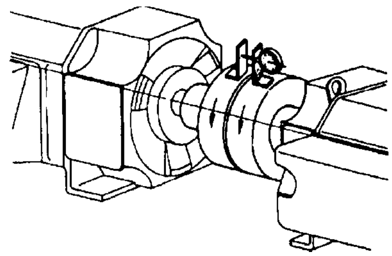
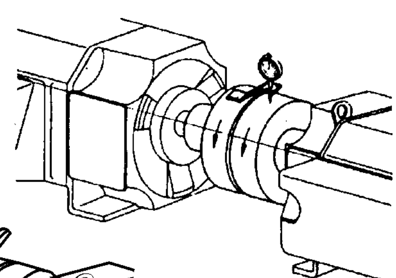


Figure 3.6a - Deviation from parallel

Figure 3.6b - Deviation from concentricity



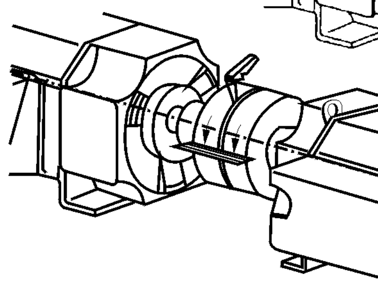


Figure 3.6c - Alignment with a steel ruler

3.1.4 Coupling

a) Direct Coupling

Direct coupling is always preferable due to its lower cost, space economy, no belt slippage and lower accident risk.
In the case of speed ratio drives, it is also common to use a direct coupling with a reducer (gear box).

CAUTION: Carefully align the shaft ends using, whenever feasible, a flexible coupling.

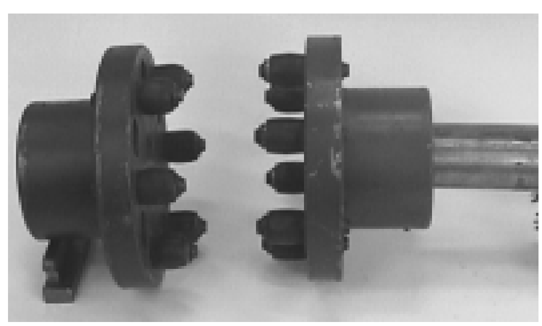


Figure 3.7 - A type of direct coupling

b) Gear Coupling

Poorly aligned gear couplings are the cause of jerking motions which bring about the vibration of the actual drive and vibrations within the motor.

Therefore, due care must be given to perfect shaft alignment: exactly parallel in the case of straight gears, and at the correct angle for bevel or helical gears.
Perfect gear engagement can be checked by the insertion of a strip of paper on which the teeth marks will be traced after a single rotation.

c) Belt and Pulley Coupling

Belt coupling is most commonly used when a speed ratio is required.
Assembly of Pulleys: To assemble pulleys on shaft ends with a keyway and threaded end holes the pulley should be inserted halfway up the keyway merely by manual pressure.
On shafts without threaded end holes the heating of the pulley to about 80°C is recommended, or alternatively, the devices illustrated in Figure 3.8 may be employed.

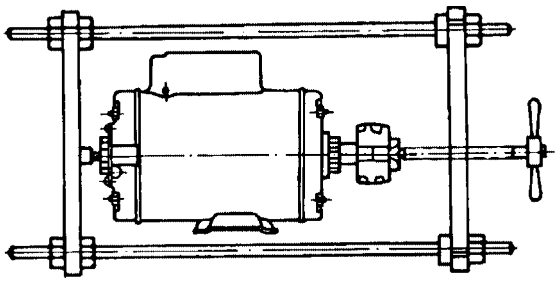


Figure 3.8 - Pulley mounting device

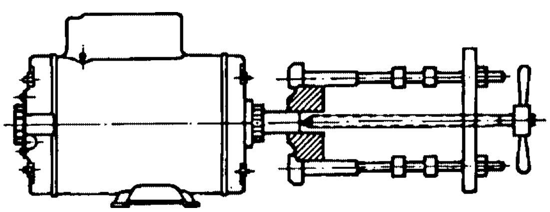


Figure 3.8a - Pulley extractor

Hammers should be avoided during the fitting of pulleys and bearings. The fitting of bearings with the aid of hammers leaves blemishes on the bearing races. These initially small flaws increase with usage and can develop to a stage that completely impairs the bearing.
The correct positioning of a pulley is shown in Figure 3.9.

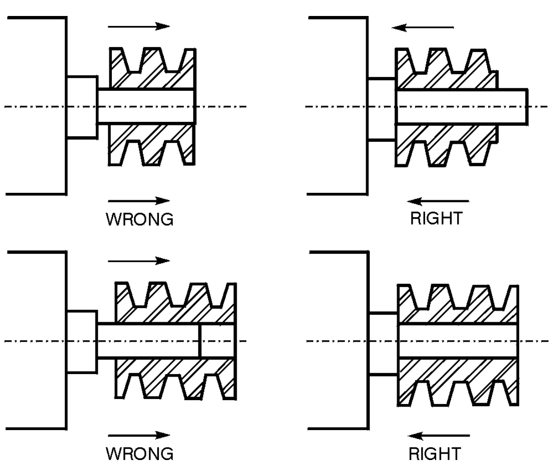


Figure 3.9 - Correct positioning of pulley on the shaft

RUNNING: To avoid needless radial stresses on the bearings it is imperative that shafts are parallel and the pulleys perfectly aligned. (Figure 3.10).

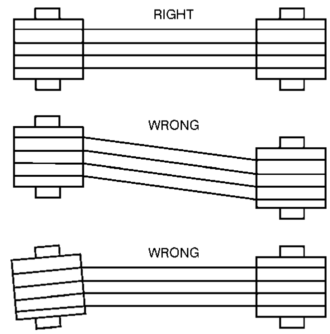


Figure 3.10 - Correct pulley alignment

Laterally misaligned pulleys, when running, transmit alternating knocks to the rotor and can damage the bearing housing. Belt slippage can be avoided by applying a resin (rosin for example).
Belt tension should be sufficient to avoid slippage during operation (Figure 3.11).
Pulleys that are too small should be avoided; these cause shaft flexion because belt traction increases in proportion to a decrease in the pulley size. Table 1 determines minimum pulley diameters, and Tables 2 and 3 refer to the maximum stresses acceptable on motor bearings up to frame 580. Beyond frame size 600, an analysis should be requested from the WEG engineering.

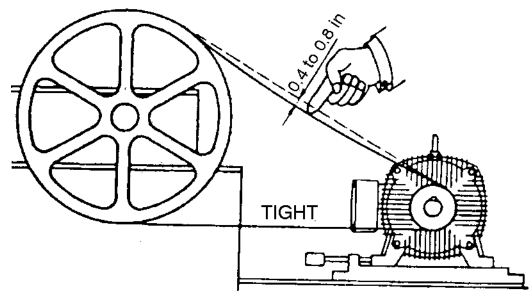
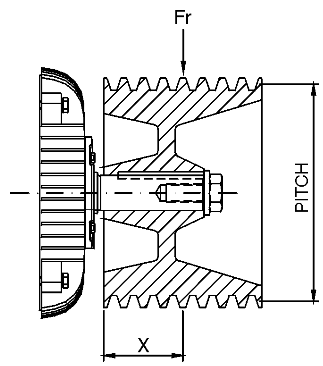


Figure 3.11 - Belt tensions

***Table 1** - Minimum pitch diameter of pulleys*

Frame	Ball bearings						
	Bearing	Size X Inches					
		0.79	1.57	2.36	3.15	3.94	4.72
140	6205-Z	1.7	1.85	2			
W 180	6206-Z	3.03	3.23	3.46			
180	6307-Z	1.69	1.81	1.93			
W 210	6308-Z		2.86	3.00	3.16		
210	6308-Z		2.90	3.06	3.22		
W 250	6309 C3		4.37	4.54	4.72	4.92	
250	6309 C3		4.41	4.59	4.77	4.97	
280	6311 C3			5.08	5.19	5.47	5.65
320	6312 C3			7.44	7.76	7.94	8.18
360	6314 C3			8.73	9.00	9.28	9.57



Frame	Poles	Ball Bearing					Roller Bearing						
		Bearing	Size X Inches				Bearing	Size X Inches					
			1.97	3.15	4.33	5.51		1.97	3.15	4.33	5.51	6.69	8.27
400	II	6314 C3	7.3	7.62	7.94	8.24		-	-	-	-	-	-
	IV-VI-VII	6314 C3					NU 316	4.13	4.31	4.49	4.67	4.85	-
440	II	6314 C3	11.75	12.16	12.61	13.08		-	-	-	-	-	-
	IV-VI-VIII	6319 C3					NU 319	4.02	4.17	4.32	4.47	4.62	4.82
500	II	6314 C3	23.54	24.34	25.12	25.87		-	-	-	-	-	-
	IV-VI-VIII	6319 C3					NU 319	6.52	6.73	6.95	7.17	7.39	7.67
5008	II	6314 C3	44.66	45.79	46.98	48.23		-	-	-	-	-	-
	IV-VI-VIII	6322 C3					NU 322	8.73	8.95	9.96	11.34	12.87	14.82
580	II	6314 C3	57	58	59	60		-	-	-	-	-	-
	IV-VI-VIII	6322 C3					NU 322	10.72	10.91	11.11	11.31	11.50	11.76

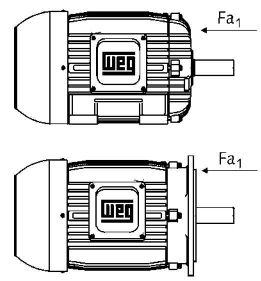
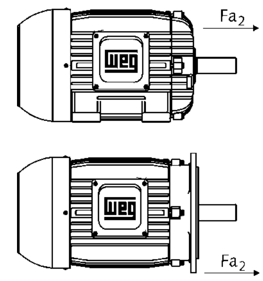
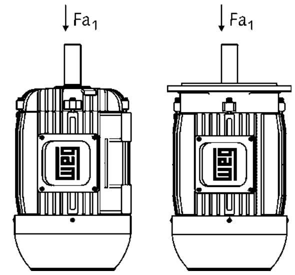
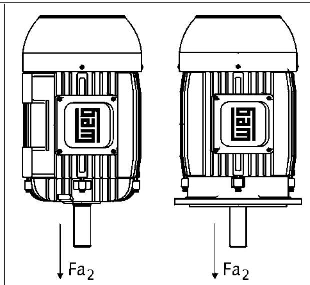
Important:
1) Peripheral speeds for solid grey cast iron pulleys FC 200 is V = 115 ft/s.
2) Use steel pulleys when peripheral speed is higher than 115 ft/s.
3) V-belt speed should not exceed 115 ft/s.

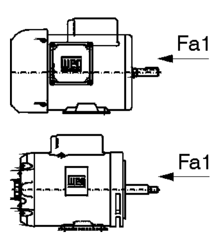
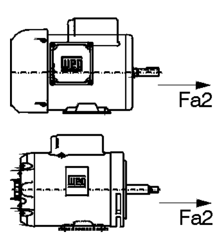
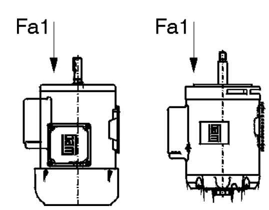
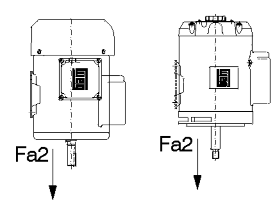
***Table 2** - Maximum acceptable radial load (Lbf)*

Frame	Nema 56 Motors			
	Radial Force (Lbf)			
	Poles	Distance X		
		1	1,18	2
56A	II	88	-	59
	IV	88	-	59
56B	II	88	-	59
	IV	86	-	59
56D	II	127	-	70
	IV	141	-	70

Saw Arbor Motors				
80 LMS	II	-	355	-
80 MMS	II	-	359	-
80 SMS	II	-	357	-
90 LMS	II		427	-
	IV	-	555	-

Table 3 *- Maximum acceptable axial load (Lbf)*

IP55 Totally Enclosed Motors - 60Hz Position / Construction Form																
FRAME																
	II	IV	VI	VIII	II	IV	VI	VIII	II	IV	VI	VIII	II	IV	VI	VIII
140	103	141	167	187	112	152	185	207	99	132	158	178	105	143	174	198
W 180	108	145	180	202	154	209	255	286	94	130	165	183	141	194	240	269
180	149	207	249	286	269	370	443	500	136	189	229	266	253	352	421	480
W 210	196	264	326	368	329	447	544	610	176	238	297	339	310	421	518	582
210	189	257	315	357	324	443	533	599	160	220	275	310	295	405	493	553
W 250	282	372	443	485	471	620	734	811	240	317	394	414	430	564	685	743
250	273	368	436	485	463	615	727	813	220	310	379	421	410	557	672	749
280	355	480	551	624	621	826	959	1,082	275	388	427	502	540	736	838	961
320	374	498	588	668	703	930	1,091	1,232	266	366	432	511	597	793	937	1,078
360	890	1,181	1,144	1,323	890	1,181	1,375	1,552	745	985	1,144	1,323	745	985	1,144	1,323
400	877	1,148	1,347	1,521	877	1,148	1,347	1,521	705	890	1,060	1,241	705	890	1,060	1,241
440	842	1,303	1,563	1,821	842	1,303	1,563	1,821	568	884	1,109	1,488	568	884	1,109	1,488
500	769	1,250	1,481	1,728	769	1,250	1,481	1,728	355	721	844	1,190	355	721	844	1,109
5008	791	1624	1909	2137	791	1624	1909	2137	728	1548	1808	2029	728	1548	1808	2029
580	679	1,406	1,649	1,865	679	1,406	1,649	1,865	033	474	549	597	033	474	549	597

Open Motors - NEMA 56 Frames - 60Hz Position / Construction Form								
FRAME								
	II	IV	II	IV	II	IV	II	IV
56 A	68	90	83	112	63	85	79	108
56 B	66	90	81	110	63	83	77	105
56 D	63	88	105	145	59	81	101	138

The maximum radial load for each frame are determined, by graphs.

INSTRUCTIONS ON HOW TO USE THE GRAPHS

1 - Maximum radial load on shaft.
2 - Maximum radial load on bearings.

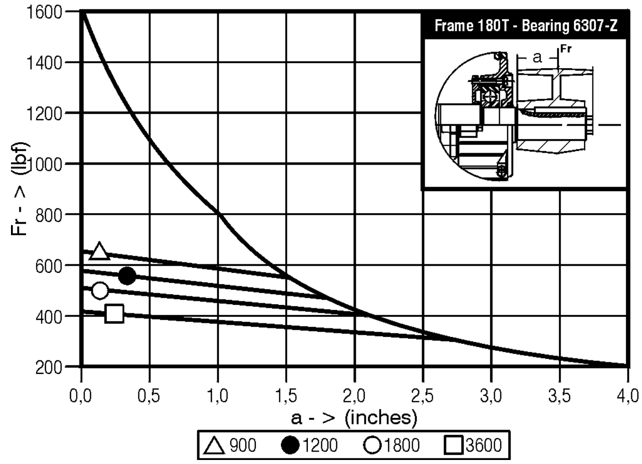
Where: X - Half of pulley width (inches)
Fr- Maximum radial load in relation to the diameter and pulley width.

Example:
Verify whether a 2HP motor, II Pole, 60Hz withstands a radial load of 110Lb, considering a pulley width of 4 inches.

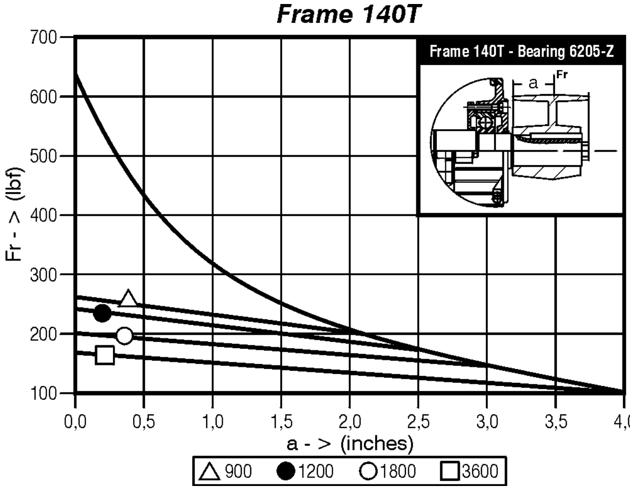
Frame: 145T
Fr: 110Lb
X: 2 inches

1 - Mark the distance X
2 - Find out line N = 3600 for bearing
Based on the above, this bearing withstands a radial load of 130Lb.

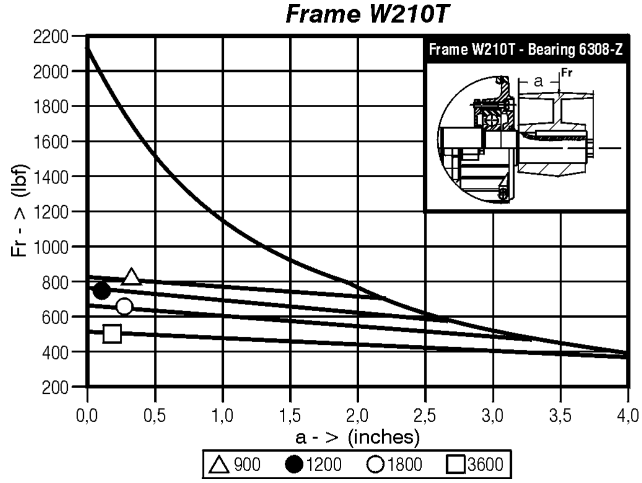
Frame 180T



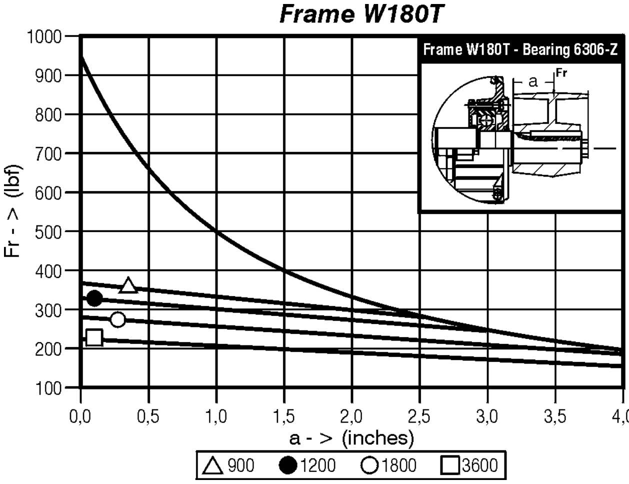
Frame 140T



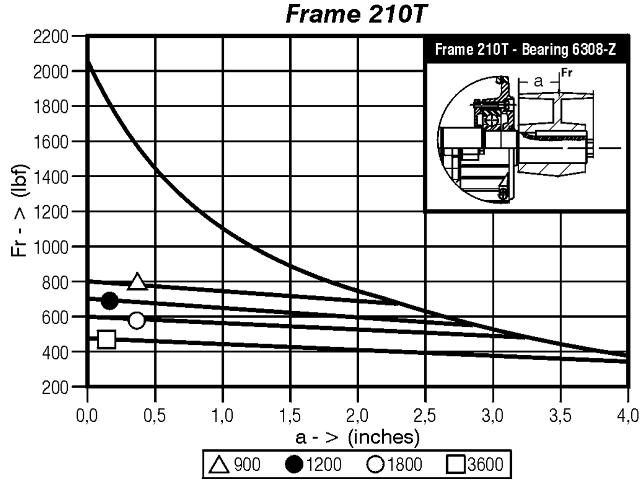
Frame W210T



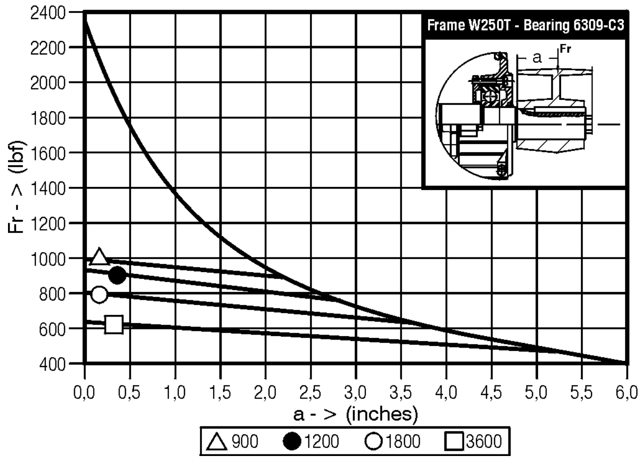
Frame W180T



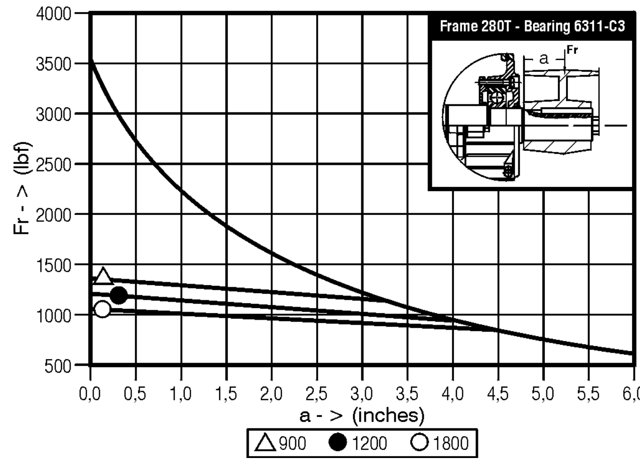
Frame 210T



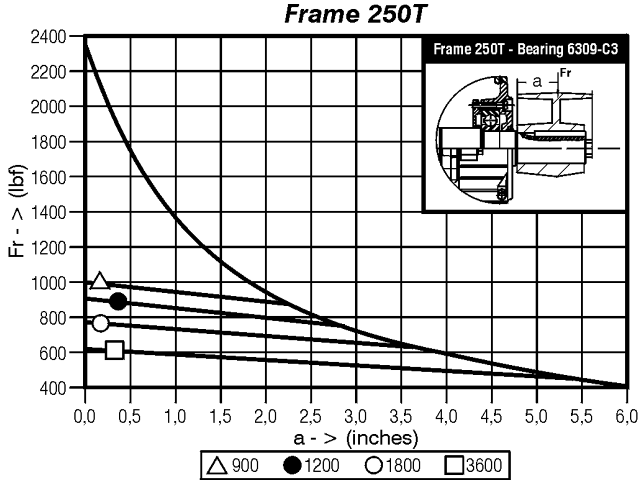
Frame W250T



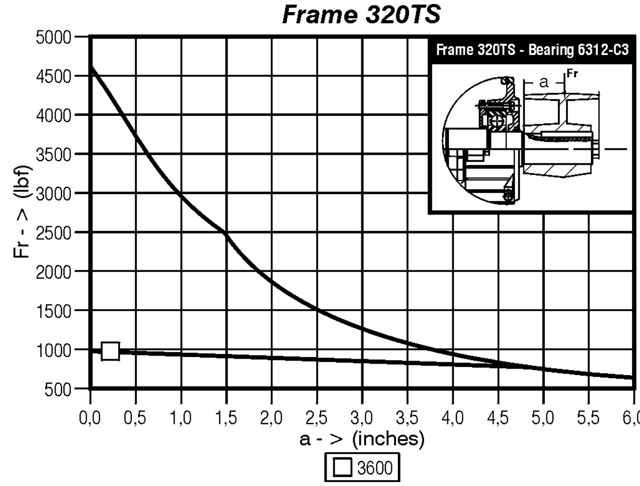
Frame 280T



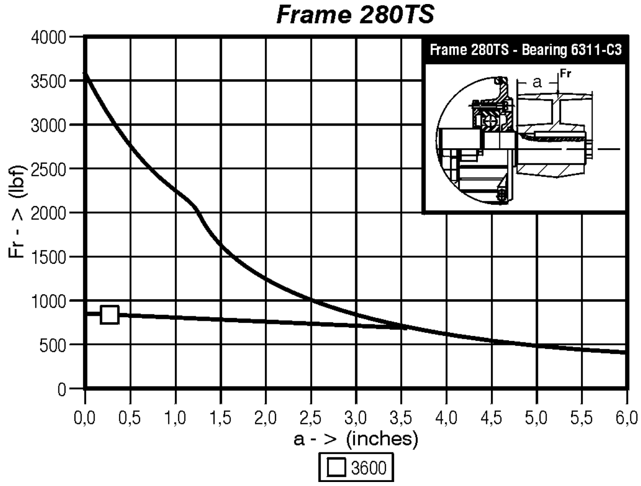
Frame 250T



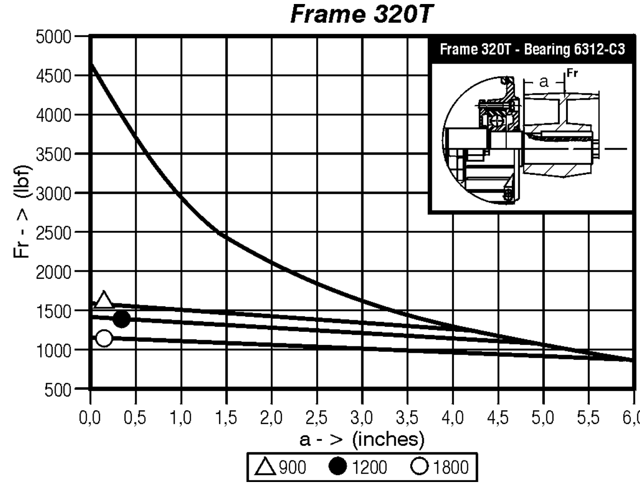
Frame 320TS



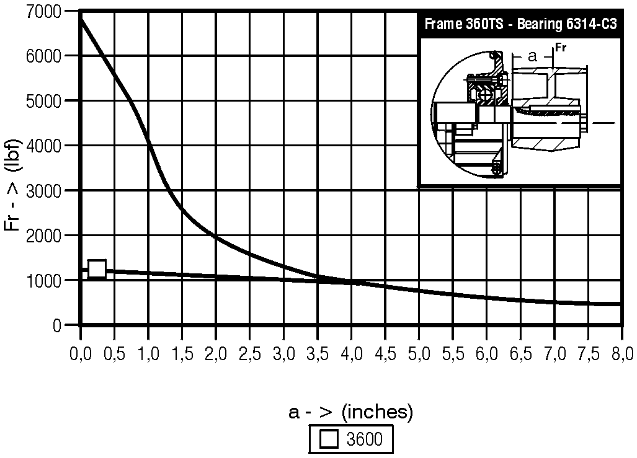
Frame 280TS



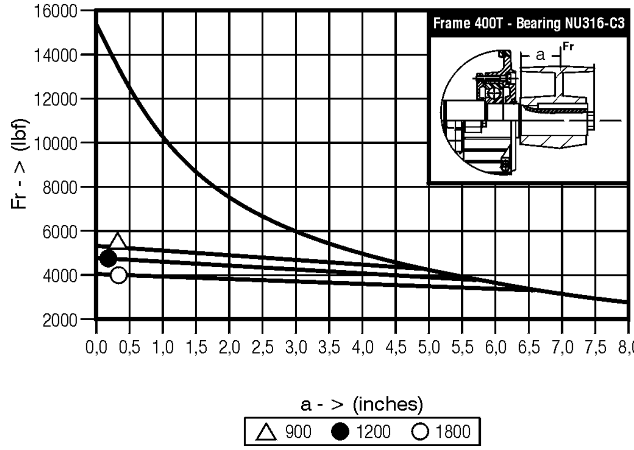
Frame 320T



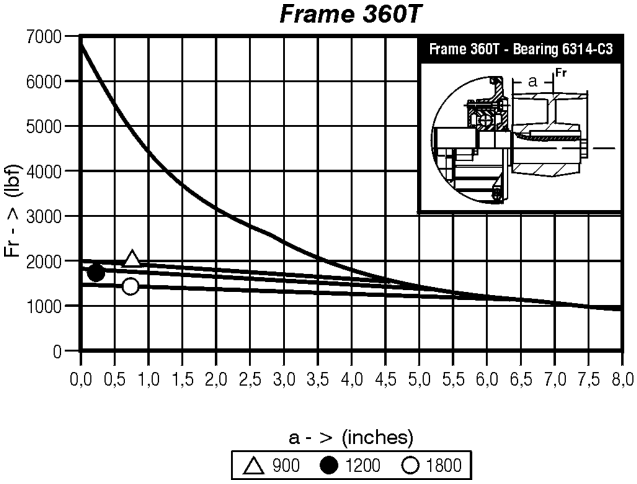
Frame 360TS



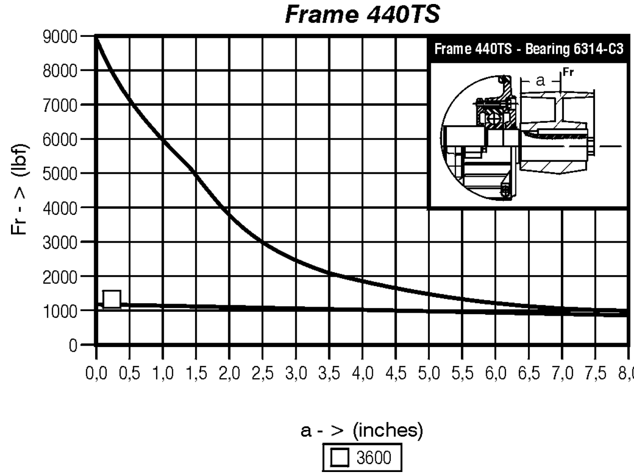
Frame 400T



Frame 360T



Frame 440TS



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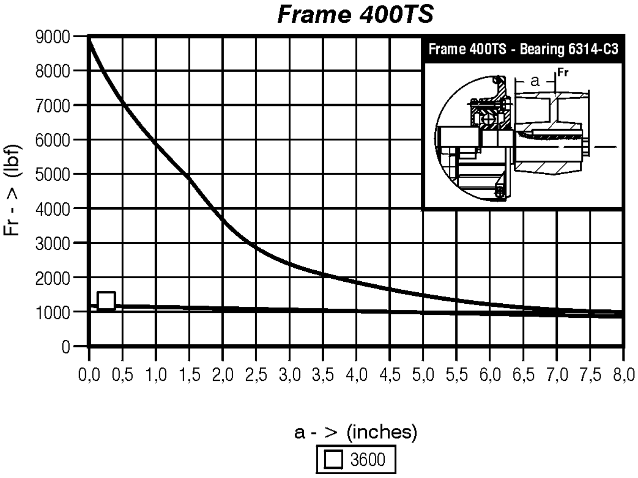

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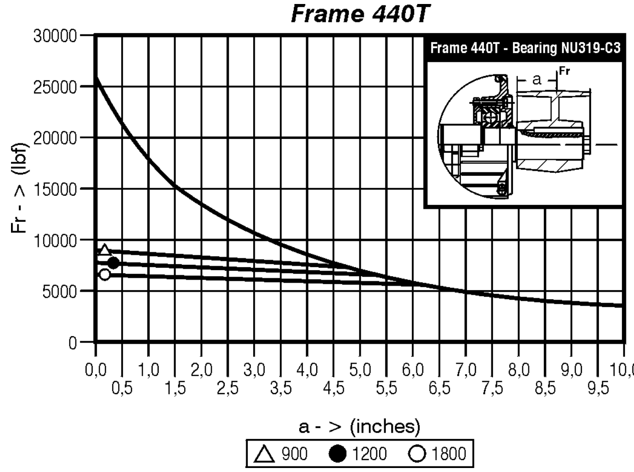
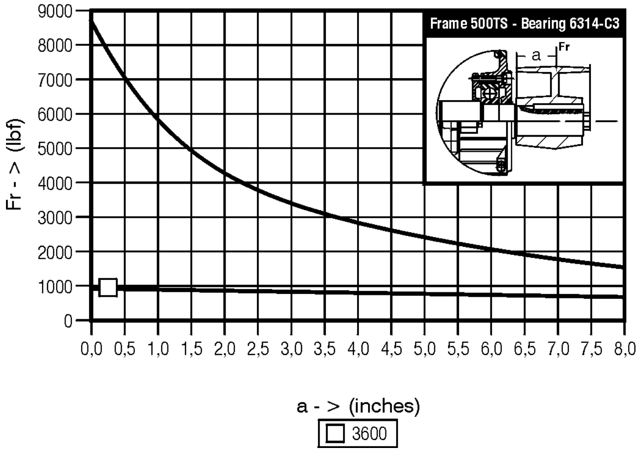
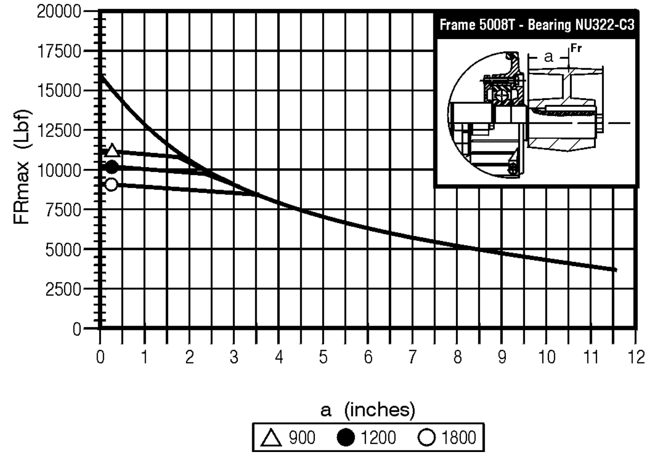


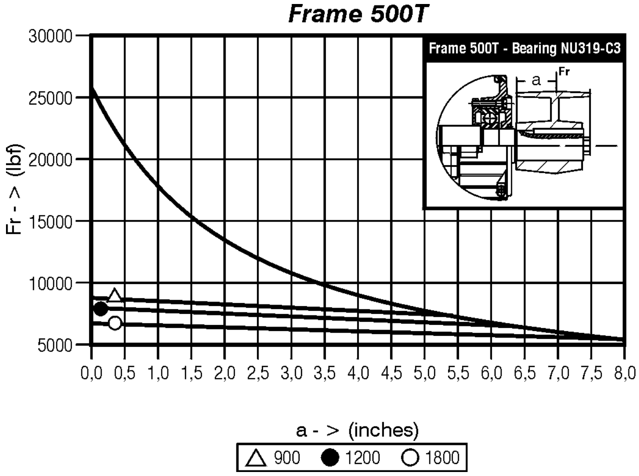
Frame 500TS



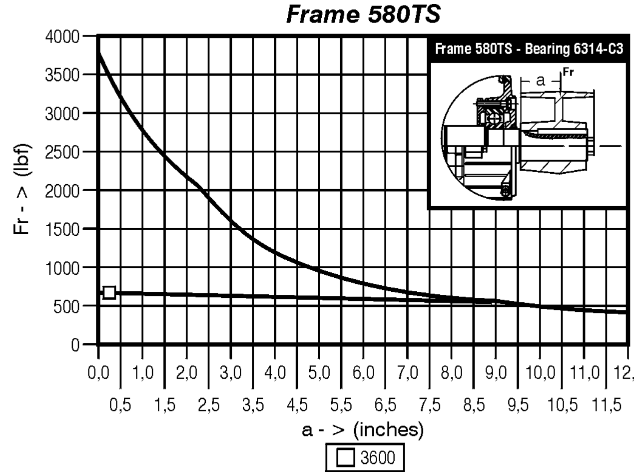
Frame 5008T



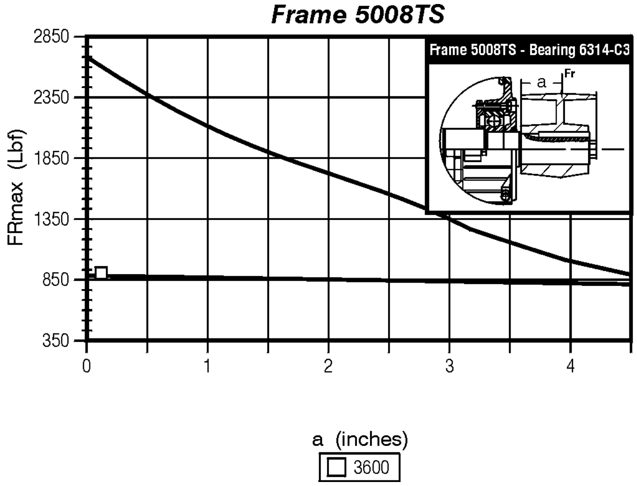
Frame 500T



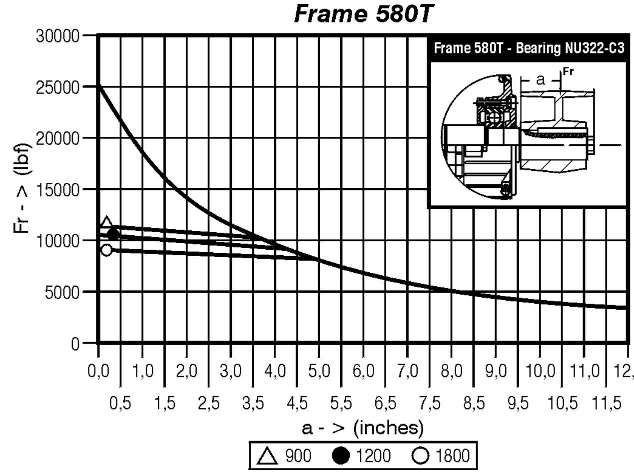
Frame 580TS



Frame 5008TS



Frame 580T



Note: For frames 600 and above, consult your engineering representative.

3.2 Electrical Aspects

3.2.1 Feed System

Proper electric power supply is very important. The choice of motor feed conductors, whether branch or distribution circuits, should be based on the rated current of the motors as per NFPA-70 Standard article 430.
Tables 4, 5 and 6 show minimum conductor gauges sized according to maximum current capacity and maximum voltage drop in relation to the distance from the distribution center to the motor, and to the type of installation (Overhead or in ducts).

To determine the conductor gauge proceed as follows:

a) Determine the current by multiplying the current indicated on the motor nameplate by 1.25 and then locate the resulting value on the corresponding table.
If the conductor feeds more than one motor, the value to be sought on the table should be equal 1.25 times the rated current of the largest motor plus the rated current of the other motors.
In the case of variable speed motors, the highest value among the rated currents should be considered.
When motor operation is intermittent, the conductors should have a current carrying capacity equal or greater, to the product of the motor rated current times the running cycle factor shown on Table 7.

***Table 7** - Running cycle factor*

Motor Short

Duty Classification \ Motor short time rating	5min	15min	30 at 60min	Continuos
Short (operating valves, activating contacts etc)	1.10	1.20	1.50	-
Intermittent (passenger or freight elevators, tools, pumps, rolling bridges etc)	0.85	0.85	0.90	1.40
Cyclic (rolling mills,mining machines etc)	0.85	0.90	0.95	1.40
Variable	1.10	1.20	1.50	2.00

b) Locate the rated voltage of the motor and the feed network distance in the upper part of the corresponding table. The point of intersection of the distance column and the line referring to current will indicate the minimum required gauge of the conductor.

Example:
Size the conductors for a 15 HP, three-phase, 230V, 42A, motor located 200 feet from the main supply with cables laid in conduits.

a) Current to be located: 1.25 x 42A = 52.5A
b) Closest value on table 6:55A
c) Minimum gauge: 6 AWG

3.2.2 Starting of Electric Motor

Induction motors can be started by the following methods:

Direct Starting

Whenever possible a three-phase motor with a squirrel cage rotor should be started directly at full supply voltage by means of a contactor (Connection diagram a). This method is called Direct-on-Line (DOL) starting.
There are DOL starter assemblies available combining a three-pole contactor, a bimetal relay (overload protection device), and a fuse (short circuit protection on branch circuit).
DOL starting is the simplest method, only feasible however, when the locked rotor current (LRC) does not influence the main electric supply lines.
Initial locked rotor current (LRC) in induction motors reach values six to eight times the value of the full load current. During starting by the DOL method, starting current can reach these high levels. The main electrical supply should be rated sufficiently, such that during the starting cycle no supply disturbance to others on the power network is caused by the voltage drop in the main supply.
This can be achieved under one of the following situations:

a) The rated main supply current is high enough for the locked rotor current not to be proportionally high.
b) Motor locked rotor current is low with no effect on the networks.
c) The motor is started under no-load conditions with a short starting cycle and, consequently, a low locked rotor current with a transient voltage drop tolerable to other consumers.

Starting with a compensating switch (auto-transformer starting)

Should direct on line starting not be possible, either due to restrictions imposed by the power supply authority or due to the installation itself, reduced voltage indirect starting methods can be employed to lower the locked rotor current. The single line connection diagram (C) shows the basic components of a compensating switch featuring a transformer (usually an auto-transformer) with a series of taps corresponding to the different values of the reduced voltage. Only three terminals of the motor are connected to the switch, the other being interconnected as per diagram, for the indicated voltage.

Star-Delta starting

It is fundamental to star-delta starting that the three-phase motor has the necessary numbers of leads for both connections:

6 leads for Y/Δ
or 12 leads for YY/ΔΔ

All the connections for the various voltages are made through terminals in the terminal box in accordance with the wiring diagram that accompanies the motor. This diagram may be shown on the nameplate or in the terminal box.
The star-delta connection is usually used only in low-voltage motors due to normally available control and protection devices. In this method of starting the locked rotor current is approximately 30% of the original LRC. The locked rotor torque is reduced proportionally as well. For this reason, it is very important before deciding to use

Table 4 *- Wire and cable gauges for single-phase motor installation (voltage drop < 5%) (in conduits)*

Supply Voltage	Distance of motor from distribution centre (feet)													
115	34	51	69	85	102	137	171	205	240	273	308	342	428	514
230	69	102	138	170	204	274	342	410	480	546	616	684	856	1028
460	138	204	276	340	408	548	684	820	960	1092	1232	1368	1712	2056
575	170	250	338	420	501	670	840	1010	1181	1342	1515	1680	2105	2530
Current (A)	Cable gauge (conductor)													
5	14	14	14	14	14	14	14	12	12	12	12	10	10	8
10	14	14	14	14	12	12	10	10	10	8	8	8	6	6
15	12	12	12	12	12	10	8	8	6	6	6	6	4	2
20	12	12	12	10	10	8	8	6	6	6	4	4	4	2
30	10	10	10	8	8	6	6	6	4	4	2	2	2	1/0
40	8	8	8	8	6	6	4	4	2	2	2	2	1/0	2/0
55	6	6	6	6	6	4	4	2	2	1/0	1/0	1/0	1/0	2/0
70	4	4	4	4	4	2	2	2	1/0	1/0	2/0	2/0	2/0	2/0
95	2	2	2	2	2	2	1/0	1/0	1/0	2/0	3/0	3/0	4/0	250M

Table 5 *- Wire and cable gauges for three-phase motor installation - aerial conductors with 25cm spacing (voltage drop < 5%)*

Supply Voltage	Distance of motor from distribution centre (feet)													
115	51	69	85	102	137	171	205	240	273	308	342	428	514	685
230	102	138	170	204	274	342	410	480	546	616	684	856	1028	1370
460	204	276	340	408	547	684	820	960	1092	1232	1368	1712	2056	2740
575	250	338	420	501	670	840	1010	1181	1342	1515	1680	2105	2530	3350
Current (A)	Cable gauge (conductor)													
15	14	14	14	12	12	10	10	10	8	8	8	6	6	4
20	14	14	12	12	10	10	8	8	8	6	6	4	4	2
30	14	12	10	8	8	8	6	6	4	4	4	2	2	1/0
40	12	10	10	8	8	6	4	4	4	2	2	2	1/0	2/0
55	10	10	8	8	6	4	4	2	2	2	1/0	2/0	3/0	--
70	8	8	6	6	4	2	2	2	1/0	1/0	2/0	3/0	--	--
100	6	6	4	4	2	2	1/0	2/0	3/0	4/0	4/0	--	--	--
130	4	4	4	2	1/0	1/0	2/0	4/0	--	--	--	--	--	--
175	2	2	2	1/0	2/0	3/0	--	--	--	--	--	--	--	--
225	1/0	1/0	1/0	2/0	3/0	--	--	--	--	--	--	--	--	--
275	2/0	2/0	2/0	4/0	--	--	--	--	--	--	--	--	--	--
320	3/0	3/0	3/0	4/0	--	--	--	--	--	--	--	--	--	--

Table 6 *- Wire and cable gauges for three-phase motor installation (voltage drop < 5%) (in conduits)*

Supply Voltage	Distance of motor from distribution centre (feet)											
115	85	102	120	137	171	205	240	273	308	342	428	514
230	170	204	240	274	342	410	480	546	616	684	856	1028
460	340	408	480	548	684	820	960	1092	1232	1368	1712	2056
575	420	501	590	670	840	1010	1181	1342	1515	1680	2105	2530
Current (A)	Cable gauge (conductor)											
15	12	12	12	10	10	8	8	8	6	6	6	4
20	12	10	10	10	8	8	6	6	6	6	4	4
30	10	8	8	8	6	6	6	4	4	4	2	2
40	8	8	6	6	6	4	4	4	2	2	2	1/0
55	6	6	6	4	4	4	2	2	2	1/0	1/0	1/0
70	4	4	4	4	2	2	2	1/0	1/0	1/0	2/0	2/0
95	2	2	2	2	2	1/0	1/0	1/0	1/0	2/0	3/0	4/0
125	1/0	1/0	1/0	1/0	1/0	1/0	2/0	2/0	3/0	3/0	4/0	250M
145	2/0	2/0	2/0	2/0	2/0	2/0	2/0	3/0	3/0	4/0	250M	300M
165	3/0	3/0	3/0	3/0	3/0	3/0	3/0	3/0	4/0	4/0	250M	350M
195	4/0	4/0	4/0	4/0	4/0	4/0	4/0	4/0	250M	250M	300M	350M
215	250M	250M	250M	250M	250M	250M	250M	250M	250M	300M	350M	400M
240	300M	300M	300M	300M	300M	300M	300M	300M	300M	300M	400M	500M
265	350M	350M	350M	350M	350M	350M	350M	350M	350M	350M	500M	500M
280	400M	400M	400M	400M	400M	400M	400M	400M	400M	400M	400M	--
320	500M	500M	500M	500M	500M	500M	500M	500M	500M	500M	500M	--

Note: The above indicated values are orientative. For guaranteed values, contact the Local Power Company.

star-delta starting to verify if the reduced locked rotor torque in “STAR” connection is enough to accelerate the load.

3.2.3 Motor Protection

Motor circuits have, in principle, two types of protection: motor overload, locked rotor and protection of branch circuit from short circuits. Motors in continuous use should be protected from overloading by means of a device incorporated into the motor, or by an independent device, usually a fixed or adjustable thermal relay equal or less than to the value derived from multiplying the rated feed current at full load by:

- 1.25 for motors with a service factor equal or superior to 1.15 or;
- 1.15 for motors with service factor equal to 1.0.

Some motors are optionally fitted with overheating protective detectors (in the event of overload, locked rotor, low voltage, inadequate motor ventilation) such as a thermostat (thermal probe), thermistor (PTC), RTD type resistance which dispense with independent devices.

THERMOSTAT (THERMAL PROBE): Bimetallic thermal detectors with normally closed silver contacts. These open at pre-determined temperatures. Thermostats are series connected directly to the contactor coil circuit by two conductors.

THERMISTORS: Semi-conductor heat detectors positive temperature coeficient (PTC) that sharply change their resistance upon reaching a set temperature. Thermistors, depending upon the type, are series or parallel-connected to a control unit that cuts out the motor feed, or actuates an alarm system, in response to the thermistors reaction.

RESISTANCE TEMPERATURE DETECTORS (RTD) - PT 100:The resistance type heat detector (RTD) is a resistance element usually manufactured of copper or platinum.
The RTD operates on the principle that the electrical resistance of a metallic conductor varies linearly with the temperature. The detector terminals are connected to a control panel, usually fitted with a temperature gauge, a test resistance and a terminal changeover switch.

Subject to the desired degree of safety and the client’s specification, three (one per phase) or six (two per phase) protective devices can be fitted to a motor for the alarm stems, circuit breaker or combined alarm and circuit breaker, with two leads from the terminal box to the alarm or circuit breaker system and four for the combined system (alarm and circuit breaker).
Table 9 compares the two methods of protection.

3.3 Start-up

3.3.1 Preliminary Inspection

Before starting a motor for the first time, it will be necessary to:

a) Remove all locking devices and blocks used in transit and check that the motor rotates freely;

b) Check that the motor is firmly secured and that coupling elements are correctly mounted and aligned.;

c) Ascertain that voltage and frequency correspond to those indicated on the nameplate. Motor performance will be satisfactory with main supply voltage fluctuation within ten per cent of the value indicated on the nameplate or a frequency fluctuation within five per cent or, yet, with a combined voltage and frequency variance within ten per cent;

d) Check that connections are in accordance with the connection diagram shown on the nameplate and be sure that all terminal screws and nuts are tight;

e) Check the motor for proper grounding. Providing that there are no specifications calling for ground-insulated installation, the motor must be grounded in accordance with prevalent standard for grounding electrical machines. The screw identified by the symbol ⏚ should be used for this purpose.
This screw is generally to be found in the terminal box or on one foot of the frame;

f) Check that motor leads connecting with the mains, as well as the control wires and the overload protection device, are in accordance with Nema Standards;

g) If the motor has been stored in a damp place, or has been stopped for some time, measure the insulating resistance as recommended under the item covering storage instructions;

h) Start the motor uncoupled to ascertain that it is turning in the desired direction. To reverse the rotation of a three-phase motor, invert two terminal leads of the mains supply.
High voltage motors bearing an arrow on the frame indicating rotation direction can only turn in the direction shown.

3.3.2 The First Start-up

Three-Phase Motor with Cage Rotor:
After careful examination of the motor, follow the normal sequence of starting operations listed in the control instructions for the initial start-up.

3.3.3 Operation

Drive the motor coupled to the load for a period of at least one hour while watching for abnormal noises or signs of overheating.
Compare the line current with the value shown on the nameplate.
Under continuous running conditions without load fluctuations this should not exceed the rated current times the service factor, also shown on the nameplate.
All measuring and control instruments and apparatus should be continuously checked for anomalies, and any irregularities corrected.

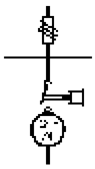
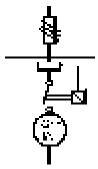
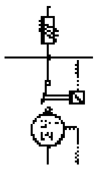
3.3.4 Stopping

Warning:

To touch any moving part of a running motor, even though disconnected, is a danger to life and limb.

Three-phase motor with cage rotor:
Open the stator circuit switch. With the motor at a complete stop, reset the auto-transformer, if any, to the “start” position.

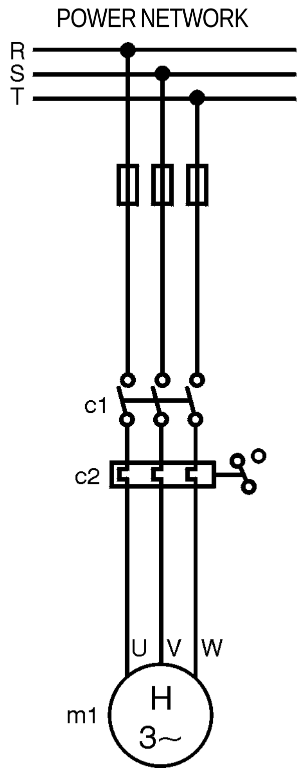
Table 9 - *Comparison between motor protection system*

Causes of overheating	Current-based protection		Protection with probe thermistor in motor
	Fuse only	Fuse and thermal protector	
			
1. Overload with 1.2 times rated current	○	●	●
2. Duty cycles S1 to S8 IEC 34, EB 120	○	◐	●
3. Brakings, reversals and frequent starts	○	◐	●
4. Operating with more than 15 starts p/hour	○	◐	●
5. Locked rotor	◐	◐	●
6. Fault on one phase	○	◐	●
7. Exececessive voltage fluctuation	○	●	●
8. Frequency fluctuation on main supply	○	●	●
9. Excessive ambient temperature	○	●	●
10. External heating caused by bearings, belts, pulleys etc.	○	○	●
11. Obstructed ventilation	○	○	●

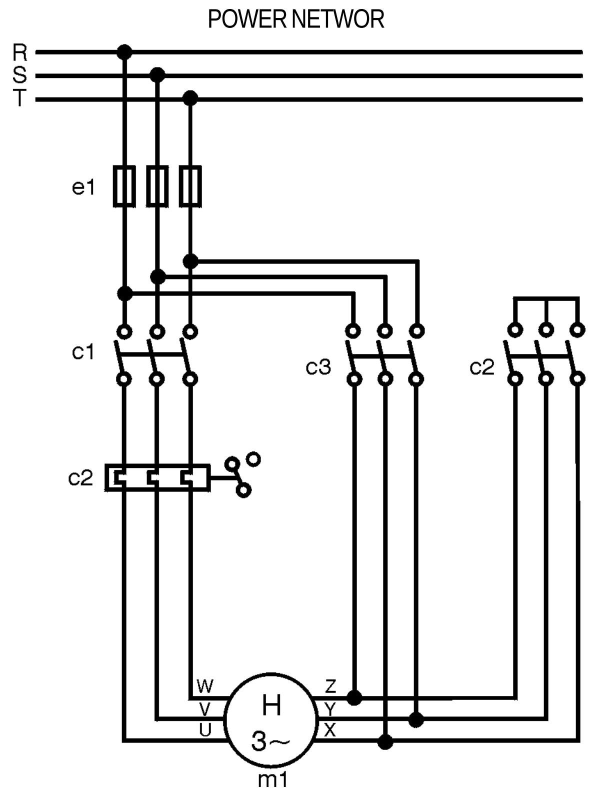
Caption:
○ unprotected
◐ partially protected
● totally protected

CONNECTION DIAGRAMS

a) Direct starting



b) Star-Delta starting



c) Auto-transformer starting

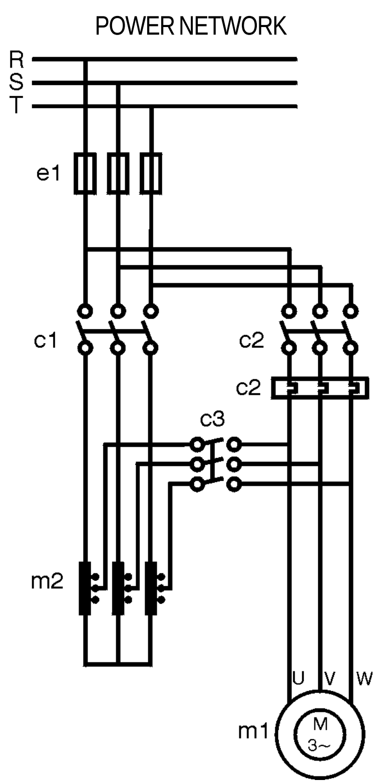


***Table 11** - Bearing specifications by type of motor*

NEMA Frames	Mounting	Bearings Front (D.E.)	Bearings Rear (O.D.E.)
Open drip proof motors			
B48 and C48	ALL FORMS	6203 Z	6202 Z
56 and A56		6203 Z	6202 Z
B56 and C56		6203 Z	6202 Z
D56 and F56H/G56H		6204 Z	6202 Z / 6203 Z
Totally enclosed fan cooled motors			
143 T	ALL FORMS	6205 ZZ	6204 ZZ
145 T		6205 ZZ	6204 ZZ
182 T		6307 ZZ	6206 ZZ
184 T		6307 ZZ	6206 ZZ
W 182 T		6206 ZZ	6205 ZZ
W 184 T		6206 ZZ	6205 ZZ
213 T		6308 ZZ	6207 ZZ
215 T		6308 ZZ	6207 ZZ
W 213 T		6308 ZZ	6207 ZZ
W 215 T		6308 ZZ	6207 ZZ
254 T		6309-C3	6209 Z-C3
256 T		6309-C3	6209 Z-C3
W 254 T		6309-C3	6209 Z-C3
W 256 T		6309-C3	6209 Z-C3
284 T and TS		6311-C3	6211 Z-C3
286 T and TS		6311-C3	6211 Z-C3
324 T and TS		6312-C3	6212 Z-C3
326 T and TS		6312-C3	6212 Z-C3
364 T and TS		6314-C3	6314-C3
365 T and TS		6314-C3	6314-C3
404 T		NU 316-C3	6314-C3
404 TS		6314-C3	6314-C3
405 T		NU 316-C3	6314-C3
405 TS		6314-C3	6414-C3
444 T		NU 319-C3	6316-C3
444 TS		6314-C3	6314-C3
445 T		NU 319-C3	6316-C3
445 TS		6314-C3	6314-C3
447 T		NU 319-C3	6316-C3
447 TS		6314-C3	6314-C3
449 T		NU 322-C3	6319-C3
449 TS		6314-C3	6314-C3
504 T		NU 319-C3	6316-C3
504 TS		6314-C3	6314-C3
505 T		NU 319-C3	6316-C3
505 TS		6314-C3	6314-C3
5008 T		NU 322-C3	6319-C3
5008TS		6314-C3	6314-C3
586 T		NU 322-C3	6319-C3
586 TS		6314-C3	6314-C3
587 T		NU 322-C3	6319-C3
587 TS		6314-C3	6314-C3

Saw Arbor motor frame	Mounting	Bearings Front (D.E.)	Bearings Rear (O.D.E.)
80 S MS	B3	6307 ZZ	6207 ZZ
80 M MS		6307 ZZ	6207 ZZ
80 L MS		6307 ZZ	6207 ZZ
90 L MS		6308 ZZ	6208 ZZ

ODP Motors Nema-T frames	Mounting	Bearings Front (D.E.)	Bearings Rear (O.D.E.)
E143/5T	HORIZONTAL MOUNTING ONLY	6205 ZZ	6204 ZZ
F143/5T		6205 ZZ	6204 ZZ
182 T		6206 ZZ	6205 ZZ
184 T		6202 ZZ	6205 ZZ
213/5T		6208 ZZ	6206 ZZ
254 T		6309 Z-C3	6209 Z-C3
256 T		6309 Z-C3	6209 Z-C3
284 T		6311 Z-C3	6211 Z-C3
284 TS		6311 Z-C3	6211 Z-C3
286 T		6311 Z-C3	6211 Z-C3
286 TS		6311 Z-C3	6211 Z-C3
324 T		6312 Z-C3	6212 Z-C3
324 TS		6312 Z-C3	6212 Z-C3
326 T		6312 Z-C3	6212 Z-C3
326 TS		6312 Z-C3	6212 Z-C3
364 T		6314 C3	6314 C3
364 TS		6314 C3	6314 C3
365 T		6314 C3	6314 C3
365 TS		6314 C3	6314 C3
404 T		NU 316 C3	6314 C3
404 TS		6314 C3	6314 C3
405 T		NU 316 C3	6314 C3
405 TS		6314 C3	6314 C3
444 T		NU 319 C3	6316 C3
444 TS		6314 C3	6314 C3
445 T		NU 319 C3	6316 C3
445 TS		6314 C3	6314 C3

IEC frame	Mounting	Bearings Front (D.E.)	Bearings Rear (O.D.E.)
Totally enclosed fan cooled motors			
63	B3	6201 ZZ	6201 ZZ
71		6203 ZZ	6202 ZZ
80		6204 ZZ	6203 ZZ
90 S - L		6205 ZZ	6204 ZZ
100 L		6206 ZZ	6205 ZZ
112 M		6307 ZZ	6206 ZZ
132 S - M		6308 ZZ	6207 ZZ
160 M - L		6309-C3	6209 Z-C3
180 M - L		6311-C3	6211 Z-C3
200 M - L		6312-C3	6212 Z-C3
225 S/M		6314-C3	6314-C3
250 S/M		6314-C3	6314-C3
280 S/M		6314-C3	6314-C3
		6316-C3	6316-C3
315 S/M		6314-C3	6314-C3
		6319-C3	6316-C3
355 M/L		6314-C3	6314-C3
		NU 322-C3	6319-C3

***Table 12** – Bearing lubrication intervals and amount of grease*

BALL BEARINGS - Series 62/63													
Relubrication intervals (running hours – horizontal position)													
	II pole		IV pole		VI pole		VIII pole		X pole		XII pole		Amount of grease
Serie 62													
Bearing	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	(g)
6209	18400	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	9
6211	14200	16500	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	11
6212	12100	14400	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	13
Serie 63													
Bearing	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	(g)
6309	15700	18100	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	13
6311	11500	13700	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	18
6312	9800	11900	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	21
6314	3600	4500	9700	11600	14200	16400	17300	19700	19700	20000	20000	20000	27
6316	-	-	8500	10400	12800	14900	15900	18700	18700	20000	20000	20000	34
6319	-	-	7000	9000	11000	13000	14000	17400	17400	18600	18600	20000	45
6322	-	-	5100	7200	9200	10800	11800	15100	15100	15500	15500	19300	60

***Table 13** – Bearing lubrication intervals and amount of grease*

BALL BEARINGS - Series NU3													
Relubrication intervals (running hours – horizontal position)													
	II pole		IV pole		VI pole		VIII pole		X pole		XII pole		Amount of grease
Bearing	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	60Hz	50Hz	(g)
NU 309	9800	13300	20000	20000	20000	20000	20000	20000	20000	20000	20000	20000	13
NU 311	6400	9200	19100	20000	20000	20000	20000	20000	20000	20000	20000	20000	18
NU 312	5100	7600	17200	20000	20000	20000	20000	20000	20000	20000	20000	20000	21
NU 314	1600	2500	7100	8900	11000	13100	15100	16900	16900	19300	19300	20000	27
NU 316	-	-	6000	7600	9500	11600	13800	15500	15500	17800	17800	20000	34
NU 319	-	-	4700	6000	7600	9800	12200	13700	13700	15700	15700	20000	45
NU 322	-	-	3300	4400	5900	7800	10700	11500	11500	13400	13400	17300	60
NU 324	-	-	2400	3500	5000	6600	10000	10200	10200	12100	12100	15000	72

Notes:

- The ZZ bearings from 6201 to 6307 do not require relubrication as its life time is about 20,000 hours.
- Tables 1 and 2 are intended for the lubrication period under bearing temperature of 70ºC (for bearings up to 6312 and NU 312) and temperature of 85ºC (for bearings 6314 and NU 314 and larger).
- For each 15ºC of temperature rise, the relubrication period is reduced by half.
- The relubrication periods given above are for those cases applying Polyrex® EM grease.
- When motors are used on the vertical position, their relubrication interval is reduced by half if compared to horizontal position motors.

Compatibility of Polyrex® EM grease with other types of grease:

Containing polyurea thickener and mineral oil, the Polyrex® EM grease is compatible with other types of grease that contain:

- Lithium base or complex of lithium or polyurea and highly refined mineral oil.
- Inhibitor additive against corrosion, rust and anti-oxidant additive.

Notes:

- Although Polyrex® EM is compatible with types of grease given above, we do no recommended to mix it with any other greases.
- If you intend to use a type of grease different than those recommended above , first contact WEG.
- On applications (with high or low temperatures, speed variation, etc), the type of grease and relubrification interval are given on an additional nameplate attached to the motor.

4. Maintenance

A well-designed maintenance program for electric motors can be summed up as: periodical inspection of insulation levels, temperature rise, wear, bearing lubrication and the occasional checking of fan air flow.
Inspection cycles depend upon the type of motor and the conditions under which it operates.

4.1 Cleanliness

Motors should be kept clean, free of dust, debris and oil. Soft brushes or clean cotton rags should be used for cleaning. A jet of compressed air should be used to remove non-abrasive dust from the fan cover and any accumulated grime from the fan and cooling fins.
Oil or damp impregnated impurities can be removed with rags soaked in a suitable solvent.
Terminal boxes fitted to motors with IP55 protection should be cleaned; their terminals should be free of oxidation, in perfect mechanical condition, and all unused space dust-free.
Motors with IPW 55 protection are recommended for use under unfavourable ambient conditions.

4.2 Lubrication

Proper lubrication extends bearing life.

Lubrication Maintenance Includes:

a) Attention to the overall state of the bearings;
b) Cleaning and lubrication;
c) Critical inspection of the bearings.

Motor noise should be measured at regular intervals of one to four months. A well-tuned ear is perfectly capable of distinguishing unusual noises, even with rudimentary tools such as a screw driver, etc., without recourse to sophisticated listening aids or stethescopes that are available on the market.
A uniform hum is a sign that a bearing is running perfectly. Bearing temperature control is also part of routine maintenance.
Constant temperature control is possible with the aid of external thermometers or by embedded thermal elements. WEG motors are normally equipped with grease lubricated ball or roller bearings.
Bearings should be lubricated to avoid metallic contact of the moving parts, and also for protection against corrosion and wear. Lubricant properties deteriorate in the course of time and mechanical operation: furthermore, all lubricants are subject to contamination under working conditions.
For this reason lubricants must be renewed and any lubricant consumed needs replacing from time to time.

4.2.1 Periodical Lubrication

WEG motors are supplied with sufficient grease for a long running period. Lubrication intervals, the amount of grease and the type of bearing used in frames 140T to 580T are to be found in Tables 11, 12 and 13.
Lubrication intervals depend upon the size of the motor, speed, working conditions and the type of grease used.

4.2.2 Quality and Quantity of Grease

Correct lubrication is important!
Grease must be applied correctly and in sufficient quantity as both insufficient or excessive greasing are harmful.
Excessive greasing causes overheating brought about by the greater resistance encountered by the rotating parts and, in particular, by the compacting of the lubricant and its eventual loss of lubricating qualities.
This can cause seepage with the grease penetrating the motor and dripping on the coils.

GREASES FOR MOTOR BEARINGS

For operating temperatures from -30 to 170ºC	
Type	**Supplier**
Polyrex® EM	Esso

4.2.3 Lubricating Instructions

a) Frame 140T to 210T motors
Frame 140T to 210T size motors are not fitted with grease nipples. Lubrication is carried out during periodical overhauls when the motor is taken apart.

Cleaning and Lubrication of Bearings

With the motor dismantled and without extracting the bearings from the shaft, all existing grease should be removed and the bearings cleaned with Diesel oil, kerosene or other solvent, until thoroughly clean.
Refill the spaces between the balls or rollers and the bearing cages with grease immediately after washing. Never rotate bearings in their dry state after washing.
For inspection purposes apply a few drops of machine oil. During these operations maximum care and cleanliness is recommended to avoid the penetration of any impurities or dust that could harm the bearings. Clean all external parts prior to reassembly.

b) Frame 360T to 580T Motors
Motors above 360T frame size are fitted with regreasable bearing system.
The lubrication system from this frame size upwards was designed to allow the removal of all grease from the bearing races through a bleeder outlet which at the same time impedes the entry of dust or other contaminants harmful to the bearing.
This outlet also prevents injury to the bearings from the well-known problem of over-greasing.

It is advisable to lubricate while the motor is running, to allow the renewal of grease in the bearing case.
Should this procedure not be possible because of rotating parts in the proximity of the nipple (pulleys, coupling sleeves, etc.) that are hazardous to the operator the following procedure should be followed:
- Inject about half the estimated amount of grease and run the motor at full speed for approximately a minute; switch off the motor and inject the remaining grease.
The injection of all the grease with the motor at rest could cause penetration of a portion of the lubricant through the internal seal of the bearing case and hence into the motor.

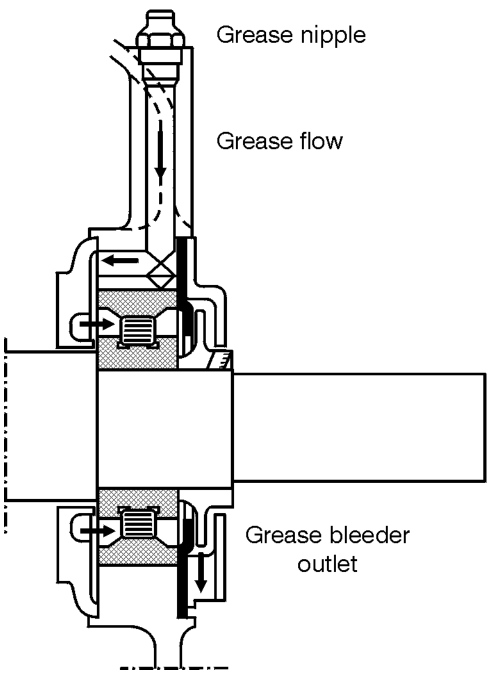


Figure 4.1 - Bearings and lubrication system

Nipples must be clean prior to introduction of grease to avoid entry of any alien bodies into the bearing.
For lubricating use only a manual grease gun.

Bearing Lubrication Steps

1. Cleanse the area around the grease nipples with clean cotton fabric.
2. With the motor running, add grease with a manual grease gun until the lubricant commences to be expelled from the bleeder outlet, or until the quantity of grease recommended in Tables 12 or 13 has been applied.
3. Allow the motor to run long enough to eject all excess grease.

4.2.4 Replacement of Bearings

The opening of a motor to replace a bearing should only be carried out by qualified personnel.
Damage to the core after the removal of the bearing cover can be avoided by filling the gap between the rotor and the stator with stiff paper of a proper thickness.
Providing suitable tooling is employed, disassembly of a bearing is not difficult.
The extractor grips should be applied to the sidewall of the inner ring to be stripped, or to an adjacent part.
To ensure perfect functioning and to prevent injury to the bearing parts, it is essential that the assembly be undertaken under conditions of complete cleanliness and by competent personnel.
New bearings should not be removed from their packages until the moment of assembly.
Prior to fitting a new bearing, ascertain that the shaft has no rough edges or signs of hammering.

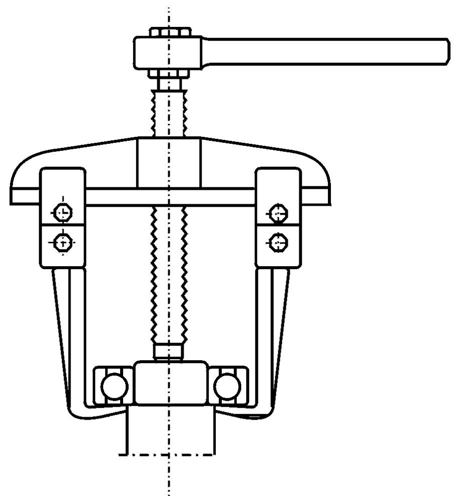


Figure 4.2 - A bearing extractor

During assembly bearings cannot be subjected to direct blows.
The aid used to press or strike the bearing should be applied to the inner ring.

4.3 Air Gap Checking (Large Rating Open Motors)

Upon the completion of any work on the bearings check the gap measurement between the stator and the rotor using the appropriate gazes.
The gap variation at any two vertically opposite points must be less than 10% of the average gap measurement.

4.4 Explosion Proof Motor Repair Steps

4.4.1 Objective

In view of the heavy liability associated with burning of motors of this type, this product has been designed and manufactured to high technical standards, under rigid controls. In addition, in many areas it is required that explosion proof motors ONLY be repaired by licensed personnel or in licensed facilities authorized to do this type of work.
The following general procedures, safeguards, and guidelines must be followed in order to ensure repaired explosion proof motors operate as intended.

4.4.2 Repair Procedure and Precautions

Dismantle the damaged motor with appropriate tools without hammering and/or pitting machined surfaces such as enclosure joints, fastening

holes, and all joints in general.
The position of the fan cover should be suitably marked prior to removal so as to facilitate reassembly later on.
Examine the motor's general condition and, if necessary, disassemble all parts and clean them with kerosene. Under no circumstances should scrapers, emery papers or tools be used that could affect the dimensions of any part during cleaning.
Protect all machined parts against oxidation by applying a coating of vaseline or oil immediately after cleaning.

STRIPPING OF WINDINGS

This step requires great care to avoid knocking and/or denting of enclosure joints and, when removing the sealing compound from the terminal box, damage or cracking of the frame.

IMPREGNATION

Protect all frame threads by inserting corresponding bolts, and the joint between terminal box and frame, by coating it with a non-adhesive varnish (ISO 287 - ISOLASIL).
Protective varnish on machined parts should be removed soon after treating with impregnating varnish. This operation should be carried out manually without using tools.

ASSEMBLY

Inspect all parts for defects, such as cracks, joint incrustations, damaged threads and other potential problems.
Assemble using a rubber headed mallet and a bronze bushing after ascertaining that all parts are perfectly fitted.
Bolts should be positioned with corresponding spring washers and evenly tightened.

TESTING

Rotate the shaft by hand while examining for any drag problems on covers or fastening rings.
Carry out running tests as for standard motors.

MOUNTING THE TERMINAL BOX

Prior to fitting the terminal box all cable outlets on the frame should be sealed with a sealing compound (Ist layer) and an Epoxy resin (ISO 340) mixed with ground quartz (2nd layer) in the following proportions:

340A resin	50 parts
340B resin	50 parts
Ground quartz	100 parts

Drying time for this mixture is two hours during which the frame should not be handled and cable outlets should be upwards.
When dry, see that the outlets and areas around the cables are perfectly sealed.
Mount the terminal box and paint the motor.

4.4.3 Miscellaneous Recommendations

- Any damaged parts (cracks, pittings in machined surfaces, defective threads) must be replaced and under no circumstances should attempts be made to recover them.
- Upon reassembling explosion proof motors IPW55 the substitution of all seals is mandatory.
- Should any doubts arise, consult WEG.

5. Malfunctioning

Most malfunctions affecting the normal running of electric motors can be prevented by maintenance and the appropriate precautions.
While ventilation, cleanliness and careful maintenance are the main factors ensuring long motor life, a further essential factor is the prompt attention to any malfunctioning as signalled by vibrations, shaft knock, declining insulation resistance, smoke or fire, sparking or unusual slip ring or brush wear, sudden changes of bearing temperatures.
When failures of an electric or mechanical nature arise, the first step to be taken is to stop the motor and subsequent examination of all mechanical and electrical parts of the installation.
In the event of fire, the installation should be isolated from the mains supply, which is normally done by turning off the respective switches.
In the event of fire within the motor itself, steps should be taken to restrain and suffocate it by covering the ventilation vents.
To extinguish a fire, dry chemical or $C0_2$ extinguishers should be used - never water.

5.1 Standard Three-Phase Motor Failures

Owing to the widespread usage of asynchronous three-phase motors in industry which are more often repaired in the plant workshops, there follows a summary of possible failures and their probable causes, detection and repairs.
Motors are generally designed to Class B or F insulation and for ambient temperatures up to 40°C.
Most winding defects arise when temperature limits, due to current overload, are surpassed throughout the winding or even in only portions thereof. These defects are identified by the darkening or carbonizing of wire insulation.

5.1.1 Short Circuits Between Turns

A short circuit between turns can be a consequent of two coinciding insulation defects, or the result of defects arising simultaneously on two adjacent wires. As wires are randomly tested, even the best quality wires can have weak spots. Weak spots can, on occasion, tolerate a voltage surge of 30% at the time of testing for shorting between turns, and later fail due to humidity, dust or vibration.
Depending on the intensity of the short, a magnetic hum becomes audible.
In some cases, the three-phase current imbalance can be so insignificant that the motor protective device fails to react. A short circuit between turns, and phases to ground due to insulation failure is rare, and even so, it nearly always occurs during the early stages of operation.

5.1.2 Winding Failures

a) One burnt winding phase

This failure arises when a motor runs wired in delta and current fails in one main conductor.
Current rises from 2 to 2.5 times in the remaining winding with a simultaneous marked fall in speed. If the motor stops, the current will increase from 3.5 to 4 times its rated value.
In most instances, this defect is due to the absence of a protective switch, or else the switch has been set too high.

b) Two burnt winding phases

This failure arises when current fails in one main conductor and the motor winding is star-connected. 0ne of the winding phases remains currentless while the others absorb the full voltage and carry an excessive current.
The slip almost doubles.

c) Three burnt winding phases

Probable cause 1
Motor only protected by fuses; an overload on the motor will be the cause of the trouble.
Consequently, progressive carbonizing of the wires and insulation culminate in a short circuit between turns, or a short against the frame occurs.
A protective switch placed before the motor would easily solve this problem.

Probable cause 2
Motor incorrectly connected. For example: A motor with windings designed for 230/400V is connected through a star-delta switch to 400V connection.
The absorted current will be so high that the winding will burn out in a few seconds if the fuses or a wrongly set protective switch fail to react promptly.

Probable cause 3
The star-delta switch is not commutated and the motor continues to run for a time connected to the star under overload conditions.
As it only develops 1/3 of its torque, the motor cannot reach rated speed. The increased slip results in higher ohmic losses arising from the Joule effect. As the stator current, consistent with the load, may not exceed the rated value for the delta connection, the protective switch will not react.
Consequent to increased winding and rotor losses the motor will overheat and the winding burn out.

Probable cause 4
Failures from this cause arise from thermal overload, due to too many starts under intermittent operation or to an overly long starting cycle.
The perfect functioning of motor operating under these conditions is only assured when the following values are heeded:
a) number of starts per hour;
b) starting with or without load;
c) mechanical brake or current inversion;
d) acceleration of rotating masses connected to motor shaft;
e) load torque vs. speed during acceleration and braking.

The continuous effort exerted by the rotor during intermittent starting brings about heavier losses which provoke overheating.
Under certain circumstances with the motor idle there is a possibility that the stator winding is subjected to damage as a result of the

heating of the motor. In such a case, a slip ring motor is recommended as a large portion of the heat (due to rotor losses) is dissipated in the rheostat.

5.1.3 Rotor Failures

If a motor running under load conditions produces a noise of varying intensity and decreasing frequency while the load is increased, the reason, in most cases, will be an unsymmetrical rotor winding.
In squirrel-cage motors the cause will nearly always be a break in one or more of the rotor bars; simultaneously, periodical stator current fluctuations may be recorded. As a rule, this defect appears only in molded or die cast aluminum cages.
Failures due to spot heating in one or another of the bars in the rotor stack are identified by the blue coloration at the affected points.
Should there be failures in various contiguous bars, vibrations and shuddering can occur as if due to an unbalance, and are often interpreted as such. When the rotor stack acquires a blue or violet coloration, it is a sign of overloading.
This can be caused by overly high slip, by too many starts or overlong starting cycles. This failure can also arise from insufficient main voltage.

5.1.4 Bearing Failures

Bearing damage is a result of overloading brought about by an overly taut belt or axial impacts and stresses.
Underestimating the distance between the drive pulley and the driven pulley is a common occurrence.
The arc of contact of the belt on the drive pulley thus becomes inadmissibly small and thereby belt tension is insufficient for torque transmission.
In spite of this it is quite usual to increase belt tension in order to attain sufficient drive.
Admittably, this is feasible with the latest belt types reinforced by synthetic materials.
However, this practice fails to consider the load on the bearing and the result is bearing failure within a short time.
Additionally there is the possibility of the shaft being subjected to unacceptably high loads when the motor is fitted with a pulley that is too wide.

5.1.5 Shaft Fractures

Although bearings traditionally constitute the weaker part, and the shafts are designed with wide safety margins, it is not beyond the realm of possibility that a shaft may fracture by fatigue from bending stress brought about by excessive belt tension.
In most cases, fractures occur right behind the drive end bearing.
As a consequence of alternating bending stress induced by a rotating shaft, fractures travel inwards from the outside of the shaft until the point of rupture is reached when resistance of the remaining shaft cross-section no longer suffices.
Avoid additional drilling the shaft (fastening screw holes) as such operations tend to cause stress concentration.

5.1.6 Unbalanced V-Belt Drives

The substitution of only one of a number of other parallel belts on a drive is frequently the cause of shaft fractures, as well as being malpractice.
Any used, and consequently stretched belts retained on the drive, especially those closest to the motor, while new and unstretched belts are placed on the same drive turning farther from the bearing, can augment shaft stress.

5.1.7 Damage Arising from Poorly Fitted Transmission Parts or Improper Motor Alignment

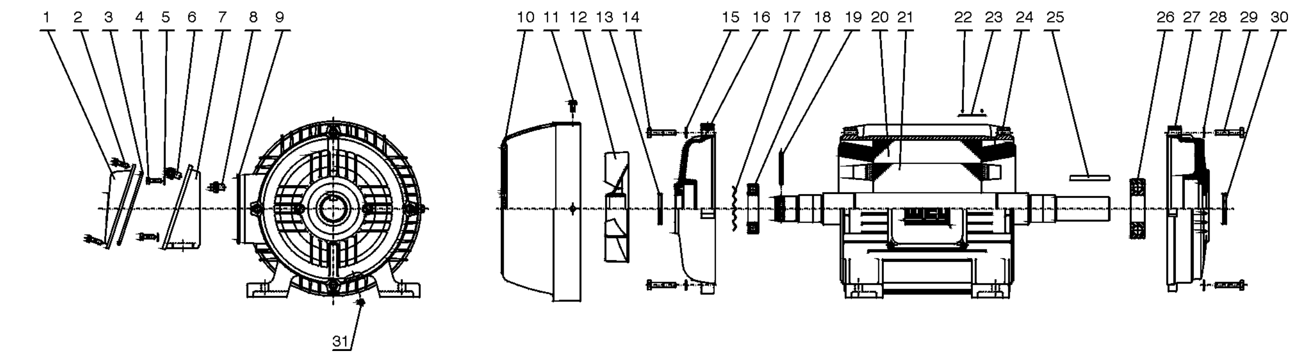
Damage to bearing and fracture in shafts often ensue from inadequate fitting of pulleys, couplings or pinions. There parts “knock” when rotating. The defect is recognized by the scratches that appear on the shaft or the eventual scalelike flaking of the shaft end.
Keyways with edges pitted by loosely fitted keys can also bring about shaft failures.
Poorly aligned couplings cause knocks and radial and axial shaking to shaft and bearings.
Within a short while these malpractices cause the deterioration of the bearings and the enlargement of the bearing cover bracket located on the drive end side.
Shaft fracture can occur in more serious cases.

5.2 Troubleshooting chart

FAILURE	PROBABLE CAUSE	CORRECTIVE MEASURES
Motor fails to start	• No voltage supply • Low voltage supply • Wrong control connections • Loose connection at some terminal lug • Overload	• Check feed connections to control system and from this to motor. • Check voltage supply and ascertain that voltage remains within 10% of the rated voltage shown on the motor nameplate. • Compare connections with the wiring diagram on the motor nameplate. • Tighten all connections. • Try to start motor under no-load conditions. If it starts, there may be an overload condition or a blocking of the starting mechanism. Reduce load to rated load level and increase torque.
High noise level	• Unbalance • Distorted shaft • Incorrect alignment • Uneven air gap • Dirt in the air gap • Extraneous matter stuck between fan and motor casing • Loose motor foundation • Worn bearings	• Vibrations can be eliminated by balancing rotor. If load is coupled directly to motor shaft, the load can be unbalanced. • Shaft key bent; check rotor balance and eccentricity. • Check motor aligment with machine running. • Check shaft for warping or bearing wear. • Dismantle motor and remove dirt or dust with jet of dry air. • Dismantle motor and clean. Remove trash or debris from motor vicinity. • Tighten all foundation studs. If necessary, realign motor. • Check lubrication. Replace bearing if noise is excessive and continuous.
Overheating of bearings	• Excessive grease • Excessive axial or radial strain on belt • Deformed shaft • Rough bearing surface • Loose or poorly fitted motor end shields • Lack of grease • Hardened grease cause locking of balls • Foreign material in grease	• Remove grease bleeder plug and run motor until excess grease is expelled. • Reduce belt tension. • Have shaft straightened and check rotor balance. • Replace bearings before they damage shaft. • Check end shields for close fit and tightness around circumference. • Add grease to bearing. • Replace bearings. • Flush out housings and relubricate.
Intense bearing vibration	• Unbalanced rotor • Dirty or worn bearing • Bearing rings too tight on shaft and/or bearing housing • Extraneous solid particles in bearing	• Balance rotor statically and dynamically. • If bearing rings are in perfect condition, clean and relubricate the bearing, otherwise, replace bearing. • Before altering shaft or housing dimensions, it is advisable to ascertain that bearing dimensions correspond to manufacturer's specifications. • Take bearing apart and clean. Reassemble only if rotating and support surfaces are unharmed.
Overheating of motor	• Obstructed cooling system • Overload • Incorrect voltages and frequecies • Frequent inversions • Rotor dragging on stator • Unbalanced electrical load (burnt fuse, incorrect control)	• Clean and dry motor; inspect air vents and windings periodically. • Check application, measuring voltage and current under normal running conditions. • Compare values on motor nameplate with those of mains supply. Also check voltage at motor terminals under full load. • Exchange motor for another that meets needs. • Check bearing wear and shaft curvature. • Check for unbalanced voltages or operation under single-phase condition.

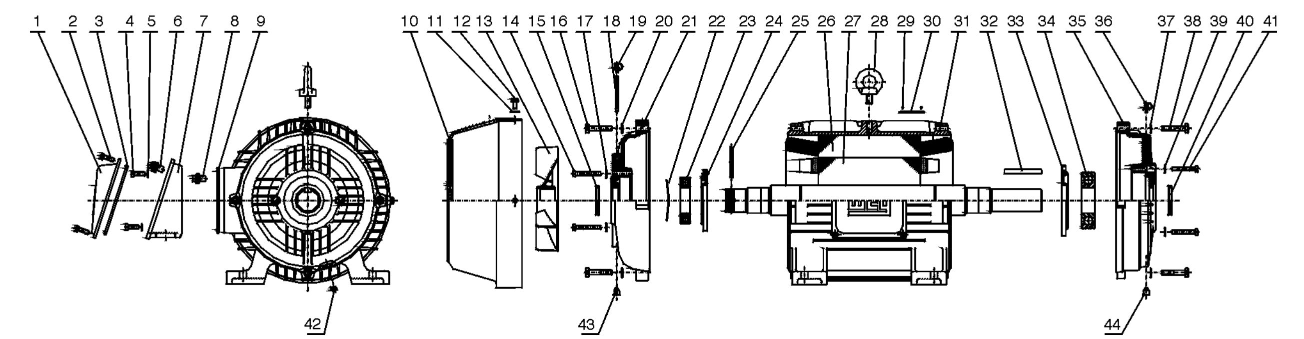
6. Spare Parts and Component Terminology

THREE-PHASE MOTORS IP55 NEMA
Frames 140T - W180T - 180T - 210T and W210T



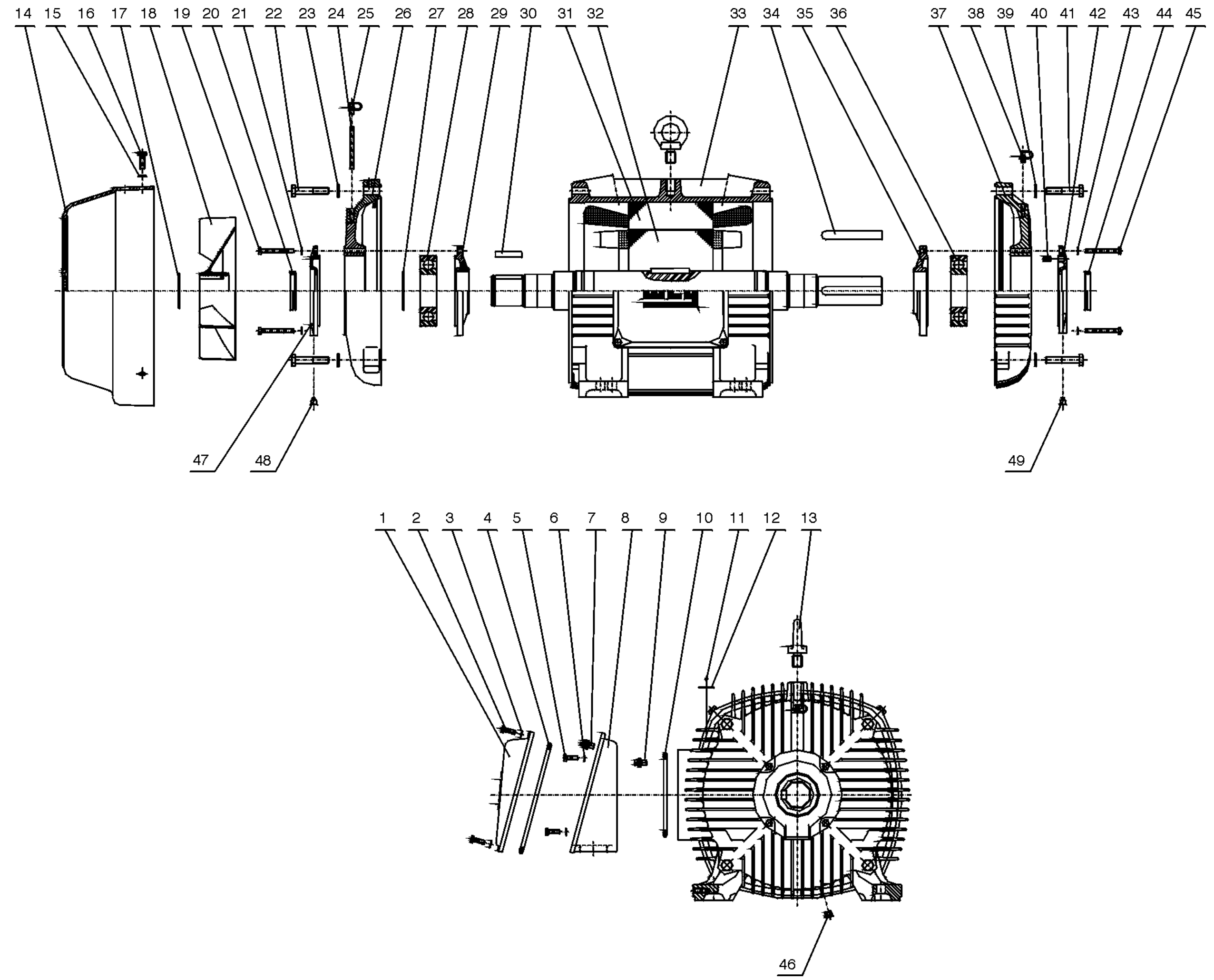
Part Nr.	Description
1	Terminal box cover
2	Terminal box cover fixing bolt
3	Terminal box cover gasket
4	Terminal box fixing bolt
5	Terminal box fixing washer
6	Terminal box grounding lug
7	Terminal box
8	Frame grounding lug
9	Terminal box o'ring gasket
10	Fan cover
11	Fan cover fixing bolt
12	Fan
13	V'Ring
14	Non-drive end endshield fixing bolt
15	Non-drive end endshield washer
16	Non-drive endshield
17	Spring washer
18	Non-drive bearing
19	Fan fixing pin
20	Wound stator
21	Rotor / shaft assembly
22	Nameplate fixing rivet
23	Nameplate
24	Frame
25	Shaft key
26	Drive end bearing
27	Drive endshield
28	Drive endshield washer
29	Drive end endshield fixing bolt
33	V'Ring
31	Drain plug

THREE-PHASE MOTORS IP55 NEMA
Frames 250T - W250T - 280T and 320T



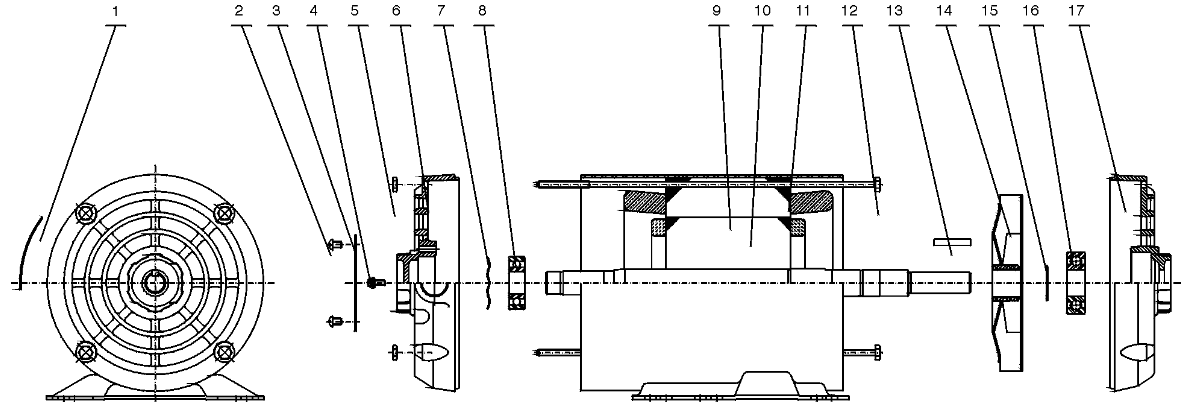
Part Nr.	Description
1	Terminal box cover
2	Terminal box cover fixing bolt
3	Terminal box cover gasket
4	Terminal box fixing bolt
5	Terminal box fixing washer
6	Terminal box grounding lug
7	Terminal box
8	Frame grounding lug
9	Terminal box o'ring gasket
10	Fan cover
11	Fan cover washer
12	Fan cover fixing bolt
13	Fan
14	Non-drive end bearing cap bolt
15	V'Ring
16	Non-drive end endshield fixing bolt
17	Non-drive end bearing cap washer
18	Non-drive end grease nipple
19	Non-drive end grease nipple cover
20	Non-drive end endshield washer
21	Non-drive endshield
22	Spring washer
23	Non-drive end bearing
24	Non-drive end bearing cap
25	Fan fixing pin
26	Wound stator
27	Rotor and shaft
28	Eyebolt
29	Nameplate fixing rivet
30	Nameplate
31	Frame
32	Shaft key
33	Drive end bearing cap
34	Drive end bearing
35	Drive andshield
36	Drive end grease nipple cover
37	Drive endshield washer
38	Drive end endshield fixing bolt
39	Drive end bearing cap washer
40	V'Ring
41	Drive end bearing cap fixing bolt
42	Drain plug
43	Non-drive and grease relief
44	Drive end grease relief

THREE-PHASE MOTORS IP55 NEMA T
Frames 360T - 400T - 440T - 500T and 580T



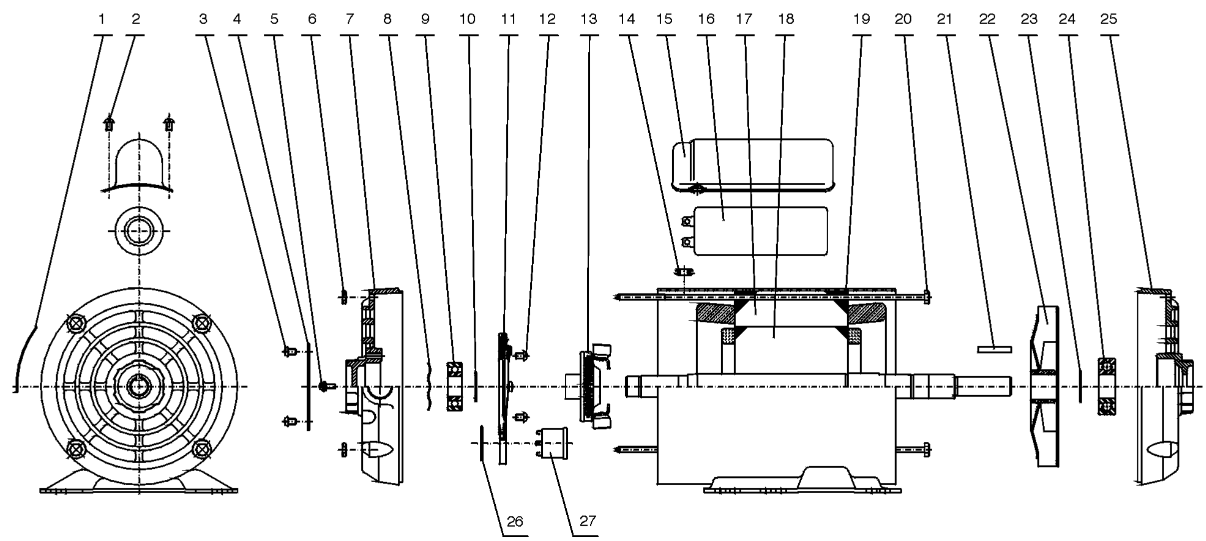
Part Nr.	Description
1	Terminal box cover
2	Terminal box cover fixing bolt
3	Terminal box cover washer
4	Terminal box cover gasket
5	Terminal box fixing bolt
6	Terminal box fixing washer
7	Terminal box grounding lug
8	Terminal box
9	Frame grounding lug
10	Terminal box o'ring gasket
11	Nameplate fixing rivet
12	Nameplate
13	Eyebolt
14	Fan cover
15	Fan cover washer
16	Fan cover fixing bolt
17	Fan fixing ring
18	Fan
19	Non-drive end bearing cap bolt
20	V'Ring
21	Non-drive end bearing cap washer
22	Non-drive end endshield fixing bolt
23	Non-drive end endshield washer
24	Non-drive end grease nipple
25	Non-drive end grease nipple cover
26	Non-drive enshield
27	Bearing cap
28	Non-drive bearing
29	Internal non-drive end bearing cap
30	Fan fixing key
31	Wound stator
32	Rotor / shaft assembly
33	Frame
34	Shaft key
35	Internal drive end bearing cap
36	Drive end bearing
37	Drive endshield
38	Drive end grease nipple cover
39	Drive endshield washer
40	Pre-load spring
41	Drive end endshield fixing bolt
42	External drive end bearing cap
43	Drive end bearing cap washer
44	V'Ring
45	Drive end bearing cap fixing bolt
46	Drain plug
47	External non-drive end bearing cap
48	Non drive end grease relief
49	Non-drive end grease relief

THREE-PHASE MOTORS NEMA 56
Frames A56 - B56 - D56 - F56H and G56H



Part Nr.	Description
1	Sticker
2	Terminal box cover fixing bolt
3	Terminal box cover
4	Grounding lug
5	Through bolt fastening nut
6	Non-drive endshield
7	Spring washer
8	Non-drive end bearing
9	Wound stator
10	Rotor / shaft assembly
11	Frame
12	Through bolt
13	Shaft key
14	Fan
15	Drive end bearing fastening washer
16	Drive end bearing
17	Drive endshield

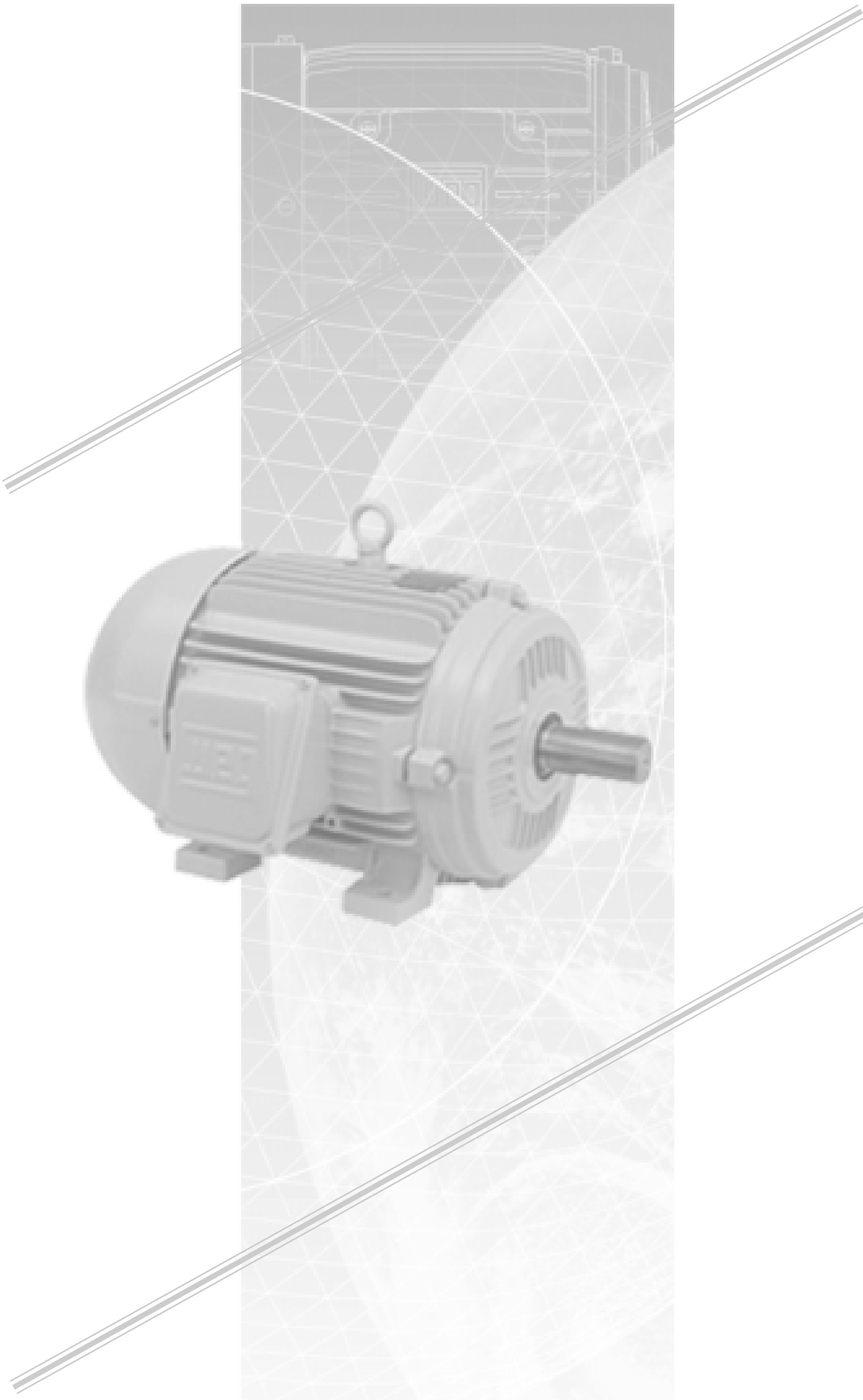
SINGLE-PHASE MOTORS NEMA 56
Frames B48 - C48 - C56 - A56 - B56 - D56 - F56H - G56H



Part Nr.	Description
1	Sticker
2	Capacitor cover fixing bolt
3	Terminal box cover fixing bolt
4	Terminal box cover
5	Grounding lug
6	Through bolt fastening nut
7	Non-drive endshield
8	Spring washer
9	Non-drive and bearing
10	Non-drive and bearing fastening washer
11	Stationary switch
12	Stationary switch fastening bolt
13	Centrifugal switch
14	Rubber ring for lead passing hole to capacitor
15	Capacitor cover
16	Capacitor
17	Wound stator
18	Rotor / shaft assembly
19	Frame
20	Through bolt
21	Shaft key
22	Fan
23	Drive end bearing fastening washer
24	Drive end bearing
25	Drive endshield
26	Overload thermal protector fixing ring
27	Overload thermal protector

Note: *For F56H and G56H frame motors: 1) Part nr. 2 = 3 pieces; 2) Part nr. 15 and 16 = 2 pieces*

NOTES:



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