# Submersible Motors

## Application ◆ Installation ◆ Maintenance

### 60 Hz, Single and Three Phase Motors

August 2000 Edition

Franklin Electric

The Company You Trust Deep Down

**ATTENTION!**
**IMPORTANT INFORMATION FOR INSTALLERS OF THIS EQUIPMENT!**

THIS EQUIPMENT IS INTENDED FOR INSTALLATION BY TECHNICALLY QUALIFIED PERSONNEL. FAILURE TO INSTALL IT IN COMPLIANCE WITH NATIONAL AND LOCAL ELECTRICAL CODES, AND WITH FRANKLIN ELECTRIC RECOMMENDATIONS, MAY RESULT IN ELECTRICAL SHOCK OR FIRE HAZARD, UNSATISFACTORY PERFORMANCE, AND EQUIPMENT FAILURE. FRANKLIN INSTALLATION INFORMATION IS AVAILABLE FROM PUMP MANUFACTURERS AND DISTRIBUTORS, AND DIRECTLY FROM FRANKLIN ELECTRIC. CALL FRANKLIN TOLL FREE 800-348-2420 FOR INFORMATION.

**WARNING**

SERIOUS OR FATAL ELECTRICAL SHOCK MAY RESULT FROM FAILURE TO CONNECT THE MOTOR, CONTROL ENCLOSURES, METAL PLUMBING, AND ALL OTHER METAL NEAR THE MOTOR OR CABLE, TO THE POWER SUPPLY GROUND TERMINAL USING WIRE NO SMALLER THAN MOTOR CABLE WIRES. TO REDUCE RISK OF ELECTRICAL SHOCK, DISCONNECT POWER BEFORE WORKING ON OR AROUND THE WATER SYSTEM. DO NOT USE MOTOR IN SWIMMING AREAS.

**ATTENTION!**
**INFORMATIONS IMPORTANTES POUR L'INSTALLATEUR DE CET EQUIPEMENT.**

CET EQUIPEMENT DOIT ETRE INTALLE PAR UN TECHNICIEN QUALIFIE. SI L'INSTALLATION N'EST PAS CONFORME AUX LOIS NATIONALES OU LOCALES AINSI QU'AUX RECOMMANDATIONS DE FRANKLIN ELECTRIC, UN CHOC ELECTRIQUE, LE FEU, UNE PERFORMANCE NON ACCEPTABLE, VOIRE MEME LE NON-FONCTIONNEMENT PEUVENT SURVENIR. UN GUIDE D'INSTALLATION DE FRANKLIN ELECTRIC EST DISPONIBLE CHEZ LES MANUFACTURIERS DE POMPES, LES DISTRIBUTEURS, OU DIRECTEMENT CHEZ FRANKLIN. POUR DE PLUS AMPLES RENSEIGNEMENTS, APPELEZ SANS FRAIS LE 800-348-2420.

**AVERTISSEMENT**

UN CHOC ELECTRIQUE SERIEUX OU MEME MORTEL EST POSSIBLE, SI L'ON NEGLIGE DE CONNECTER LE MOTEUR, LA PLOMBERIE METALLIQUE, BOITES DE CONTROLE ET TOUT METAL PROCHE DU MOTEUR A UN CABLE ALLANT VERS UNE ALIMENTATION D'ENERGIE AVEC BORNE DE MISE A LA TERRE UTILISANT AU MOINS LE MEME CALIBRE QUE LES FILS DU MOTEUR. POUR REDUIRE LE RISQUE DE CHOC ELECTRIQUE. COUPER LE COURANT AVANT DE TRAVAILLER PRES OU SUR LE SYSTEM D'EAU. NE PAS UTILISER CE MOTEUR DANS UNE ZONE DE BAIGNADE.

**ATENCION!**
**INFORMACION PARA EL INSTALADOR DE ESTE EQUIPO.**

PARA LA INSTALACION DE ESTE EQUIPO, SE REQUIERE DE PERSONAL TECNICO CALIFICADO. EL NO CUMPLIR CON LAS NORMAS ELECTRICAS NACIONALES Y LOCALES, ASI COMO CON LAS RECOMENDACIONES DE FRANKLIN ELECTRIC DURANTE SU INSTALACION, PUEDE OCASIONAR, UN CHOQUE ELECTRICO, PELIGRO DE UN INCENDIO, OPERACION DEFECTUOSA E INCLUSO LA DESCOMPOSTURA DEL EQUIPO. LOS MANUALES DE INSTALACION Y PUESTA EN MARCHA DE LOS EQUIPOS, ESTAN DISPONIBLES CON LOS DISTRIBUIDORES, FABRICANTES DE BOMBAS O DIRECTAMENTE CON FRANKLIN ELECTRIC. PUEDE LLAMAR GRATUITAMENTE PARA MAYOR INFORMACION AL TELEFONO 800-348-2420.

**ADVERTENCIA**

PUEDE OCURRIR UN CHOQUE ELECTRICO, SERIO O FATAL DEBIDO A UNA ERRONEA CONECCION DEL MOTOR, DE LOS TABLEROS ELECTRICOS, DE LA TUBERIA, DE CUALQUIER OTRA PARTE METALICA QUE ESTA CERCA DEL MOTOR O POR NO UTILIZAR UN CABLE PARA TIERRA DE CALIBRE IGUAL O MAYOR AL DE LA ALIMENTACION. PARA REDUCIR EL RIESGO DE CHOQUE ELECTRIC, DESCONECTAR LA ALIMENTACION ELECTRICA ANTES DE INICIAR A TRABAJAR EN EL SISTEMA HIDRAULICO. NO UTILIZAR ESTE MOTOR EN ALBERCAS O AREAS EN DONDE SE PRACTIQUE NATACION.

# Commitment To Quality

Franklin Electric is committed to provide customers with defect free products through our program of continuous improvement. Quality shall, in every case, take precedence over quantity.

Franklin Electric

# Submersible Motors

## Application • Installation • Maintenance Manual

The submersible motor is a reliable, efficient and trouble-free means of powering a pump. Its needs for a long operational life are simple. They are:

1. A suitable operating environment
2. An adequate supply of electricity
3. An adequate flow of cooling water over the motor
4. An appropriate pump load

All considerations of application, installation, and maintenance of submersible motors relate to these four areas. This manual will acquaint you with these needs and assist you if service or maintenance is required.

## Contents

## Storage

Franklin Electric submersible motors are a water-lubricated design. The fill solution consists of a mixture of de-ionized water and Propylene Glycol (a non-toxic antifreeze). The solution will prevent damage from freezing in temperatures to -40°F (-40°C); motors should be stored in areas that do not go below this temperature. The solution will partially freeze below 27°F (-3°C), but no damage occurs. Repeated freezing and thawing should be avoided to prevent possible loss of fill solution.

There may be an interchange of fill solution with well water during operation. Care must be taken with motors removed from wells during freezing conditions to prevent damage.

When the storage temperature does not exceed 100°F (37°C), storage time should be limited to two years. Where temperatures reach 100° to 130°F, storage time should be limited to one year.

Loss of a few drops of liquid will not damage the motor as an excess amount is provided, and the filter check valve will allow lost liquid to be replaced by filtered well water upon installation. If there is reason to believe there has been a considerable amount of leakage, consult the factory for checking procedures.

## Frequency of Starts

The average number of starts per day over a period of months or years influences the life of a submersible pumping system. Excessive cycling affects the life of control components such as pressure switches, starters, relays and capacitors. Rapid cycling can also cause motor spline damage, bearing damage, and motor overheating. All these conditions can lead to reduced motor life.

The pump size, tank size and other controls should be selected to keep the starts per day as low as practical for longest life. The maximum number of starts per 24-hour period is shown in Table 3.

Motors should run a minimum of one minute to dissipate heat build up from starting current.

**Table 3 Number of Starts**

| Motor Rating | | Max Starts Per 24 Hr. Period | |
|---|---|---|---|
| HP | KW | Single Phase | Three Phase |
| Up to .75 HP | Up to .55 | 300 | 300 |
| 1 thru 5.5 | .75 thru 4 | 100 | 300 |
| 7.5 thru 30 | 5.5 thru 22 | 50 | 100 |
| 40 and over | 30 and over | | 100 |

## Mounting Position

Franklin submersible motors are designed primarily for operation in the vertical, shaft-up position.

During acceleration, the pump thrust increases as its output head increases. In cases where the pump head stays below its normal operating range during startup and full speed condition, the pump may create upward thrust. This creates upward thrust on the motor upthrust bearing. This is an acceptable operation for short periods at each start, but running continuously with upthrust may cause excessive wear on the upthrust bearing.

With certain restrictions, motors are also suitable for operations in positions from shaft-up to shaft-horizontal. As the mounting position becomes further from vertical and closer to horizontal, the probability of shortened thrust bearing life increases. For normal thrust bearing life expectancy with motor positions other than shaft-up, follow these recommendations:

1. Minimize the frequency of starts, preferably to fewer than 10 per 24-hour period.
2. Do not use in systems which can run even for short periods at full speed without thrust toward the motor.

## Transformer Capacity - Single Phase or Three Phase

Distribution transformers must be adequately sized to satisfy the KVA requirements of the submersible motor. When transformers are too small to supply the load, there is a reduction in voltage to the motor.

Table 4 references the motor horsepower rating, single phase and three phase, total effective KVA required, and the smallest transformer required for open or closed three phase systems. Open systems require larger transformers since only two transformers are used.

Other loads would add directly to the KVA sizing requirements of the transformer bank.

**Table 4 Transformer Capacity**

| Motor Rating | | Total Effective KVA Required | Smallest KVA Rating-Each Transformer | |
|---|---|---|---|---|
| HP | KW | | Open WYE or DELTA 2-Transformers | Closed WYE or DELTA 3-Transformers |
| 1.5 | 1.1 | 3 | 2 | 1 |
| 2 | 1.5 | 4 | 2 | 1.5 |
| 3 | 2.2 | 5 | 3 | 2 |
| 5 | 3.7 | 7.5 | 5 | 3 |
| 7.5 | 5.5 | 10 | 7.5 | 5 |
| 10 | 7.5 | 15 | 10 | 5 |
| 15 | 11 | 20 | 15 | 7.5 |
| 20 | 15 | 25 | 15 | 10 |
| 25 | 18.5 | 30 | 20 | 10 |
| 30 | 22 | 40 | 25 | 15 |
| 40 | 30 | 50 | 30 | 20 |
| 50 | 37 | 60 | 35 | 20 |
| 60 | 45 | 75 | 40 | 25 |
| 75 | 55 | 90 | 50 | 30 |
| 100 | 75 | 120 | 65 | 40 |
| 125 | 90 | 150 | 85 | 50 |
| 150 | 110 | 175 | 100 | 60 |
| 175 | 130 | 200 | 115 | 70 |
| 200 | 150 | 230 | 130 | 75 |

**NOTE:** Standard KVA ratings are shown. If power company experience and practice allows transformer loading higher than standard, higher loading values may be used for transformer(s) to meet total effective KVA required provided correct voltage and balance is maintained.

## Effects of Torque

During starting of a submersible pump, the torque developed by the motor must be supported through the pump, delivery pipe or other supports. Most pumps rotate in the direction which causes unscrewing torque on right-handed threaded pipe or pump stages. All threaded joints, pumps and other parts of the pump support system must be capable of withstanding the maximum torque repeatedly without loosening or breaking. Unscrewing joints will break electrical cable and may cause loss of the pump-motor unit.

To safely withstand maximum unscrewing torques with a minimum safety factor of 1.5, tightening all threaded joints to at least 10 lb. ft. per motor horsepower is recommended (Table 4A). It may be necessary to tack or strap weld pipe joints on high horsepower pumps, especially at shallower settings.

**Table 4A Torque Required (Examples)**

| Motor Rating | | HP x 10 lb.Ft. | Minimum Safe Torque-Load |
|---|---|---|---|
| HP | KW | | |
| 1 HP & Less | .75 KW & Less | 1 X 10 | 10 lb. Ft. |
| 20 HP | 15 KW | 20 X 10 | 200 lb. Ft. |
| 75 HP | 55 KW | 75 x 10 | 750 lb. Ft. |
| 200 HP | 150 KW | 200 x 10 | 2000 lb. Ft. |

## Use of Engine Driven Generators — Single Phase or Three Phase

Table 5 lists minimum generator sizes based on typical 80°C rise continuous duty generators, with 35% maximum voltage dip during starting, for Franklin's three-wire motors, single or three phase.

This is a general chart. The generator manufacturer should be consulted whenever possible, especially on larger sizes.

There are two types of generators available: externally and internally regulated. Most are externally regulated. They use an external voltage regulator that senses the output voltage. As the voltage dips at motor start-up, the regulator increases the output voltage of the generator.

Internally regulated (self-excited) generators have an extra winding in the generator stator. The extra winding senses the output current to automatically adjust the output voltage.

Generators must be sized to deliver at least 65% of the rated voltage during starting to ensure adequate starting torque. Besides sizing, generator frequency is important as the motor speed varies with the frequency (Hz). Due to pump affinity laws, a pump running at 1 to 2 Hz below motor nameplate frequency design will not meet its performance curve. Conversely, a pump running at 1 to 2 Hz above may trip overloads.

Generator Operation. Always start the generator before the motor is started and always stop the motor before the generator is shut down. The motor thrust bearing may be damaged if the generator is allowed to coast down with the motor running. This same condition occurs when the generator is allowed to run out of fuel.

Follow generator manufacturer's recommendations for de-rating at higher elevations or using natural gas.

**Table 5 Engine Driven Generators**

| Motor Rating | | Minimum Rating of Generator | | | |
|---|---|---|---|---|---|
| | | Externally Regulated | | Internally Regulated | |
| HP | KW | KW | KVA | KW | KVA |
| 1/3 | 0.25 | 1.5 | 1.9 | 1.2 | 1.5 |
| 1/2 | 0.37 | 2 | 2.5 | 1.5 | 1.9 |
| 3/4 | 0.55 | 3 | 3.8 | 2 | 2.5 |
| 1 | 0.75 | 4 | 5 | 2.5 | 3.125 |
| 1 1/2 | 1.1 | 5 | 6.25 | 3 | 3.8 |
| 2 | 1.5 | 7.5 | 9.4 | 4 | 5 |
| 3 | 2.2 | 10 | 12.5 | 5 | 6.25 |
| 5 | 3.7 | 15 | 18.75 | 7.5 | 9.4 |
| 7 1/2 | 5.5 | 20 | 25 | 10 | 12.5 |
| 10 | 7.5 | 30 | 37.5 | 15 | 18.75 |
| 15 | 11 | 40 | 50 | 20 | 25 |
| 20 | 15 | 60 | 75 | 25 | 31 |
| 25 | 18.5 | 75 | 94 | 30 | 37.5 |
| 30 | 22 | 100 | 125 | 40 | 50 |
| 40 | 30 | 100 | 125 | 50 | 62.5 |
| 50 | 37 | 150 | 188 | 60 | 75 |
| 60 | 45 | 175 | 220 | 75 | 94 |
| 75 | 55 | 250 | 313 | 100 | 125 |
| 100 | 75 | 300 | 375 | 150 | 188 |
| 125 | 90 | 375 | 469 | 175 | 219 |
| 150 | 110 | 450 | 563 | 200 | 250 |
| 175 | 130 | 525 | 656 | 250 | 313 |
| 200 | 150 | 600 | 750 | 275 | 344 |

**NOTE:** For best starting of 2-wire motors, the minimum generator rating is 50% higher than shown.

**WARNING:** To prevent accidental electrocution, automatic or manual transfer switches must be used any time a generator is used as standby or back up on power lines. Contact power company for use and approval.

## Use of Check Valves

It is recommended that one or more check valves always be used in submersible pump installations. If the pump does not have a built-in check valve, a line check valve should be installed in the discharge line within 25 feet of the pump and below the draw down level of the water supply. For deeper settings, it is recommended that line check valves be installed per the manufacturer's recommendations.

Swing type check valves are **not** acceptable and should never be used with submersible motors/pumps. Swing type check valves have a slower reaction time which can cause water hammer (see below). Internal pump check valves or spring loaded check valves close quickly and help eliminate water hammer.

Check valves are used to hold pressure in the system when the pump stops. They also prevent backspin, water hammer and upthrust. Any of these can lead to early pump or motor failure.

**NOTE:** Only positive sealing check valves should be used in submersible installations. Although drilling the check valves or using drain-back check valves may prevent back spinning, they create upthrust and water hammer problems.

**A.Backspin -** With no check valve or a failed check valve, the water in the drop pipe and the water in the system can flow down the discharge pipe when the motor stops. This can cause the pump to rotate in a reverse direction. If the motor is started while this is happening, a heavy strain may be placed across the pump-motor assembly. It can also cause excessive thrust bearing wear because the motor is not turning fast enough to ensure an adequate film of water between the thrust bearing and thrust shoes.

**B.Upthrust -** With no check valve, or with a leaking check valve, the unit starts under a zero head condition. This causes an uplifting or upthrust on the impeller-shaft assembly in the pump. This upward movement carries across the pump-motor coupling and creates an upthrust condition in the motor. Repeated upthrust can cause premature failure of both the pump and the motor.

**C.Water Hammer -** If the lowest check valve is more than 30 feet above the standing water level, or a lower check valve leaks and the check valve above holds, a partial vacuum is created in the discharge piping. On the next pump start, water moving at very high velocity fills the void and strikes the closed check valve and the stationary water in the pipe above it, causing a hydraulic shock. This shock can split pipes, break joints and damage the pump and/or motor. Water hammer is an easily detected noise. When discovered, the system should be shut down and the pump installer contacted to correct the problem.

## Wells-Large Diameter, Uncased, Top Feeding & Screened Sections

Franklin Electric submersible motors are designed to operate with a cooling flow of water over the motor.

If the pump installation does not provide the minimum flow shown in Table 6, a flow inducer sleeve (flow sleeve) must be used. The conditions requiring a flow sleeve are:

- Well diameter is too large to meet Table 6 flow requirements.
- Pump is in an open body of water.
- Pump is in a rock well or below the well casing.
- The well is “top-feeding”.
- Pump is set in or below screens or perforations.

## Water Temperature and Flow

Franklin Electric submersible motors, except 8" SEVERE DUTY (see note below), are designed to operate up to maximum service factor horsepower in water up to 86°F (30°C). A flow of 0.25 ft/sec for 4" High Thrust motors and 0.5 ft/sec for 6 and 8 inch motors is required for proper cooling. Table 6 shows minimum flow rates, in GPM, for various well diameters and motor sizes.

If the motor is operated in water over 86°F (30°C), water flow past the motor must be increased to maintain safe motor operating temperatures. See HOT WATER APPLICATIONS on Page 7.

**NOTE:** 8" SEVERE DUTY motors are designed to operate with loading up to maximum service factor horsepower in water up to 90°C (195°F) with water flow past motor of 0.5 ft/sec (0.15 m/sec).

**Table 6 Required Cooling Flow**

| Minimum GPM required for motor cooling in water up to 86°F (30°C). | | | |
|---|---|---|---|
| Casing or Sleeve I.D. Inches (mm) | 4" High Thrust Motor .25 ft/sec. GPM (l/m) | 6" Motor .50 ft/sec. GPM (l/m) | 8" Motor .50 ft/sec. GPM (l/m) |
| 4 (102) | 1.2 (4.5) | - | - |
| 5 (127) | 7 (26.5) | - | - |
| 6 (152) | 13 (49) | 9 (34) | - |
| 7 (178) | 20 (76) | 25 (95) | - |
| 8 (203) | 30 (114) | 45 (170) | 10 (40) |
| 10 (254) | 50 (189) | 90 (340) | 55 (210) |
| 12 (305) | 80 (303) | 140 (530) | 110 (420) |
| 14 (356) | 110 (416) | 200 (760) | 170 (645) |
| 16 (406) | 150 (568) | 280 (1060) | 245 (930) |

.25 ft/sec = 7.62 cm/sec .50 ft/sec = 15.24 cm/sec
1 inch = 2.54 cm

## Flow Inducer Sleeve

If the flow rate is less than specified or coming from above the pump, then a flow inducer sleeve must be used. A flow sleeve is always required in an open body of water. FIG 1 shows a typical flow inducer sleeve construction.

**EXAMPLE :** A six-inch motor and pump that delivers 60 GPM will be installed in a 10" well.

From Table 6, 90 GPM would be required to maintain proper cooling. In this case adding an 8” or smaller flow sleeve provides the required cooling.

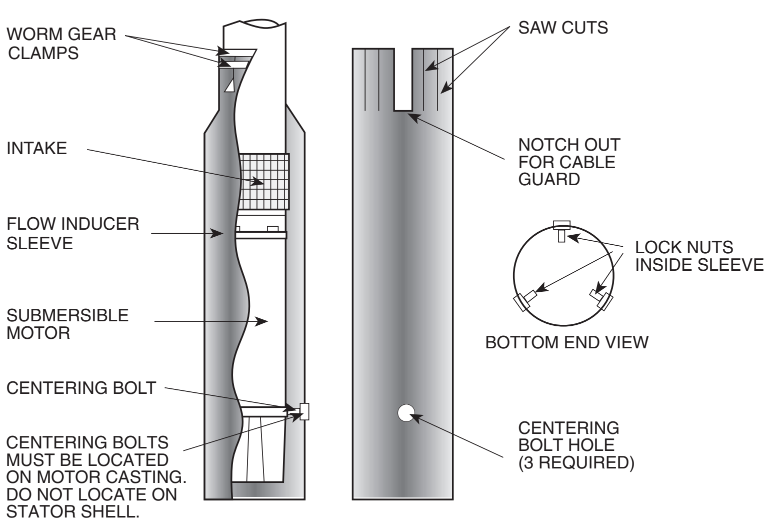



**FIG. 1**

## Head Loss From Flow Past Motor

Table 7 lists the approximate head loss due to flow between an average length motor and smooth casing or flow inducer sleeve.

**Table 7 Head Loss in Feet (Meters) at Various Flow Rates**

| | Motor Diameter | 4" | 4" | 4" | 6" | 6" | 6" | 8" | 8" |
|---|---|---|---|---|---|---|---|---|---|
| | Casing ID in Inches (mm) | 4 (102) | 5 (127) | 6 (152) | 6 (152) | 7 (178) | 8 (203) | 8.1 (206) | 10 (254) |
| Flow Rate in GPM (l/m) | 25 (95) | 0.3 (.09) | | | | | | | |
| | 50 (189) | 1.2 (.37) | | | | | | | |
| | 100 (378) | 4.7 (1.4) | 0.3 (.09) | | 1.7 (.52) | | | | |
| | 150 (568) | 10.2 (3.1) | 0.6 (.18) | 0.2 (.06) | 3.7 (1.1) | | | | |
| | 200 (757) | | 1.1 (.34) | 0.4 (.12) | 6.3 (1.9) | 0.5 (.15) | | 6.8 (2.1) | |
| | 250 (946) | | 1.8 (.55) | 0.7 (.21) | 9.6 (2.9) | 0.8 (.24) | | 10.4 (3.2) | |
| | 300 (1136) | | 2.5 (.75) | 1.0 (.30) | 13.6 (4.1) | 1.2 (.37) | 0.2 (.06) | 14.6 (4.5) | |
| | 400 (1514) | | | | 23.7 (7.2) | 2.0 (.61) | 0.4 (.12) | 24.6 (7.5) | |
| | 500 (1893) | | | | | 3.1 (.94) | 0.7 (.21) | 37.3 (11.4) | 0.6 (0.2) |
| | 600 (2271) | | | | | 4.4 (1.3) | 1.0 (.30) | 52.2 (15.9) | 0.8 (0.3) |
| | 800 (3028) | | | | | | | | 1.5 (0.5) |
| | 1000 (3785) | | | | | | | | 2.4 (0.7) |

## Hot Water Applications

When the pump-motor operates in water hotter than 86°F (30°C), a flow rate of at least 3 ft/sec is required. When selecting the motor to drive a pump in over 86°F (30°C) water, the motor horsepower must be de-rated per the following procedure.

1. Using Table 7A, determine pump GPM required for different well or sleeve diameters. If necessary, add a flow sleeve to obtain at least 3 ft/sec flow rate.

**Table 7A - Minimum GPM ( l/m) Required for 3 ft/sec ( .91 m/sec) Flow Rate**

| Casing or Sleeve I.D. | | 4" High Thrust Motor | | 6" Motor | | 8" Motor | |
|---|---|---|---|---|---|---|---|
| Inches | (mm) | GPM | (l/m) | GPM | (l/m) | US GPM | (l/m) |
| 4 | (102) | 15 | (57) | | | | |
| 5 | (127) | 80 | (303) | | | | |
| 6 | (152) | 160 | (606) | 52 | (197) | | |
| 7 | (178) | | | 150 | (568) | | |
| 8 | (203) | | | 260 | (984) | 60 | (227) |
| 10 | (254) | | | 520 | (1970) | 330 | (1250) |
| 12 | (305) | | | | | 650 | (2460) |
| 14 | (356) | | | | | 1020 | (3860) |
| 16 | (406) | | | | | 1460 | (5530) |

2. Determine pump horsepower required from the pump manufacturer's curve.

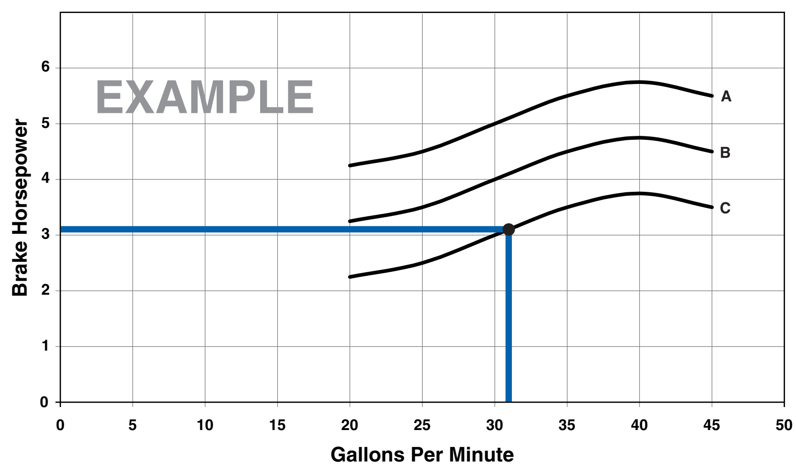



**FIG. 2 MANUFACTURER'S PUMP CURVE**

3. Multiply the pump horsepower required by the heat factor multiplier from Table 8.

**Table 8 Heat Factor Multiplier at 3 ft/sec (.91 m/sec) Flow Rate**

| Maximum Water Temperature | 1/3 - 5 HP .25 - 3.7 KW | 7 1/2 - 30 HP 5.5 - 22 KW | Over 30HP Over 22 KW |
|---|---|---|---|
| 140°F (60°C) | 1.25 | 1.62 | 2.00 |
| 131°F (55°C) | 1.11 | 1.32 | 1.62 |
| 122°F (50°C) | 1.00 | 1.14 | 1.32 |
| 113°F (45°C) | 1.00 | 1.00 | 1.14 |
| 104°F (40°C) | 1.00 | 1.00 | 1.00 |
| 95°F (35°C) | 1.00 | 1.00 | 1.00 |

4. Select a rated HP motor on Table 8A whose Service Factor Horsepower is at least the value calculated in Item 3.

**Table 8A Service Factor Horsepower**

| HP | KW | SFHP | HP | KW | SFHP | HP | KW | SFHP | HP | KW | SFHP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/3 | 0.25 | 0.58 | 3 | 2.2 | 3.45 | 25 | 18.5 | 28.75 | 100 | 75 | 115 |
| 1/2 | 0.37 | 0.8 | 5 | 3.7 | 5.75 | 30 | 22 | 34.5 | 125 | 90 | 143.75 |
| 3/4 | 0.55 | 1.12 | 7 1/2 | 5.5 | 8.62 | 40 | 30 | 46 | 150 | 110 | 175.5 |
| 1 | 0.75 | 1.4 | 10 | 7.5 | 11.5 | 50 | 37 | 57.5 | 175 | 130 | 201.25 |
| 1 1/2 | 1.1 | 1.95 | 15 | 11 | 17.25 | 60 | 45 | 69 | 200 | 150 | 230 |
| 2 | 1.5 | 2.5 | 20 | 15 | 23 | 75 | 55 | 86.25 | | | |

## Hot Water Applications - Example

**EXAMPLE:** A 6" pump end requiring 39 HP input will pump 124°F water in an 8" well at a delivery rate of 140 GPM. From Table 7A, a 6" flow sleeve will be required to increase the flow rate to at least 3 ft/sec.

Using Table 8, the 1.62 heat factor multiplier is selected because the HP required is over 30 HP and water temperature is above 122°F. Multiply 39 HP x 1.62 (multiplier), which equals 63.2 HP. This is the minimum rated service factor horsepower usable at 39 HP in 124°F. Using Table 8A, select a motor with a rated service factor horsepower above 63.2 HP. A 60 HP motor has a service factor horsepower of 69, so a 60 HP motor may be used.

For many hot water applications Franklin Electric's 8" SEVERE DUTY MOTOR is more economical than a de-rated 8" standard water well motor. See SEVERE DUTY MOTOR application manual for additional options for hot water pumping.

## Drawdown Seals

Allowable motor temperature is based on atmospheric pressure or higher surrounding the motor. “Drawdown seals,” which seal the well to the pump above it’s intake to maximize delivery, are not recommended, since the suction created can be lower than atmospheric pressure.

## Grounding Control Boxes and Panels

The National Electrical Code requires that the control box or panel-grounding terminal always be connected to supply ground. If the circuit has no grounding conductor and no metal conduit from the box to supply panel, use a wire at least as large as line conductors and connect as required by the National Electrical Code, from the grounding terminal to the electrical supply ground.

**WARNING:** Failure to ground the control frame can result in a serious or fatal electrical shock hazard if a circuit fault occurs.

## Grounding Surge Arrestors

An above ground surge arrestor must be grounded, metal to metal, all the way to the water strata for the lightning arrestor to be effective. GROUNDING THE ARRESTOR TO THE SUPPLY GROUND OR TO A DRIVEN GROUND ROD PROVIDES LITTLE OR NO PROTECTION FOR THE MOTOR.

## Control Box and Panel Environment

Franklin Electric control boxes meet UL requirements for NEMA Type 3R enclosures. They are suitable for indoor and outdoor applications within temperatures of +14°F (-10°C) to 122°F (50°C). Operating control boxes below +14° F can cause reduced starting torque and loss of overload protection when overloads are located in control boxes.

Control boxes and panels should never be mounted in direct sunlight or high temperature locations. This will cause shortened capacitor life and unnecessary tripping of overload protectors. A ventilated enclosure painted white to reflect heat is recommended for an outdoor, high temperature location.

A damp well pit, or other humid location, accelerates component failure from voltage breakdown and corrosion.

Control boxes with voltage relays are designed for vertical upright mounting only. Mounting in other positions will affect the operation of the relay.

## 3-Wire Control Boxes

Single phase three-wire submersible motors require the use of control boxes. Operation of motors without control boxes or with incorrect boxes can result in motor failure and voids warranty.

Control boxes contain starting capacitors, a starting relay, and, in some sizes, overload protectors, running capacitors and contactors.

Ratings through 1 HP may use a solid state or a potential (voltage) type starting relay, while larger ratings use potential relays.

### Potential (Voltage) Relays

Potential relays have normally closed contacts. When power is applied, both start and main motor windings are energized, and the motor starts. At this instant, the voltage across the start winding is relatively low and not enough to open the contacts of the relay.

As the motor accelerates, the increasing voltage across the start winding (and the relay coil) opens the relay contacts. This opens the starting circuit and the motor continues to run on the main winding alone, or the main plus run capacitor circuit. After the motor is started the relay contacts remain open.

**CAUTION:** Be certain that control box HP and voltage match the motor.

## 2-Wire Motor Solid State Controls

### BIAC Switch Operation

When power is applied the bi-metal switch contacts are closed so the triac is conducting and energizes the start winding. As RPM increases, the voltage in the sensor coil generates heat in the bi-metal strip, causing the bi-metal strip to bend and open the switch circuit. This removes the starting winding and the motor continues to run on the main winding alone.

Approximately 5 seconds after power is removed from the motor, the bi-metal strip cools sufficiently to return to its closed position and the motor is ready for the next start cycle. If, during operation, the motor speed drops, the lowered voltage in the sensor coil allows the bi-metal contacts to close, and bring the motor back to operating speed.

**CAUTION:** Restarting the motor within 5 seconds after power is removed may cause the motor overload to trip.

### Rapid Cycling

The BIAC starting switch will reset within approximately 5 seconds after the motor is stopped. If an attempt is made to restart the motor before the starting switch has reset, the motor may not start; however, there will be current in the main winding until the overload protector interrupts the circuit. The time for the protector to reset is longer than the reset of the starting switch. Therefore, the start switch will have closed and the motor will operate.

A waterlogged tank will cause fast cycling. When a waterlogged condition does occur, the user will be alerted to the problem during the off time (overload reset time) since the pressure will drop drastically. When the water-logged tank condition is detected the condition should be corrected to prevent nuisance tripping of the overload protector.

### Bound Pump (Sandlocked)

When the motor is not free to turn, as with a sandlocked pump, the BIAC switch creates a “reverse impact torque” in the motor in either direction. When the sand is dislodged, the motor will start and operate in the correct direction.

## QD Relays (Solid State)

There are two elements in the relay: a reed switch and a triac. The reed switch consists of two tiny rectangular blade-type contacts, which bend under magnetic flux. It is hermetically sealed in glass and is located within a coil, which conducts line current. When power is supplied to the control box, the main winding current passing through the coil immediately closes the reed switch contacts. This turns on the triac, which supplies voltage to the start winding, thus starting the motor.

Once the motor is started, the operation of the QD relay is an interaction between the triac, the reed switch and the motor windings. The solid state switch senses motor speed through the changing phase relationship between start winding current and line current. As the motor approaches running speed, the phase angle between the start current and the line current become nearly in phase. At this point, the reed switch contacts open, turning off the triac. This removes voltage from the start winding and the motor continues to run on the main winding only. With the reed switch contacts open and the triac turned off, the QD relay is ready for the next starting cycle.

## 2- or 3-Wire Cable, 60 Hz (Service Entrance to Motor - Maximum Length In Feet)

**Table 11**

| Motor Rating | | | 60° C Insulation - AWG Copper Wire Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 |
| 115 | 1/3 | .25 | 130 | 210 | 340 | 540 | 840 | 1300 | 1610 | 1960 | 2390 | 2910 | 3540 | 4210 | 5060 |
| | 1/2 | .37 | 100 | 160 | 250 | 390 | 620 | 960 | 1190 | 1460 | 1780 | 2160 | 2630 | 3140 | 3770 |
| 230 | 1/3 | .25 | 550 | 880 | 1390 | 2190 | 3400 | 5250 | 6520 | 7960 | 9690 | 11770 | | | |
| | 1/2 | .37 | 400 | 650 | 1020 | 1610 | 2510 | 3880 | 4810 | 5880 | 7170 | 8720 | | | |
| | 3/4 | .55 | 300 | 480 | 760 | 1200 | 1870 | 2890 | 3580 | 4370 | 5330 | 6470 | 7870 | | |
| | 1 | .75 | 250 | 400 | 630 | 990 | 1540 | 2380 | 2960 | 3610 | 4410 | 5360 | 6520 | | |
| | 1 1/2 | 1.1 | 190 | 310 | 480 | 770 | 1200 | 1870 | 2320 | 2850 | 3500 | 4280 | 5240 | | |
| | 2 | 1.5 | 150 | 250 | 390 | 620 | 970 | 1530 | 1910 | 2360 | 2930 | 3620 | 4480 | | |
| | 3 | 2.2 | **120** | 190 | 300 | 470 | 750 | 1190 | 1490 | 1850 | 2320 | 2890 | 3610 | | |
| | 5 | 3.7 | 0 | 0 | **180** | 280 | 450 | 710 | 890 | 1110 | 1390 | 1740 | 2170 | 2680 | |
| | 7 1/2 | 5.5 | 0 | 0 | 0 | **200** | 310 | 490 | 610 | 750 | 930 | 1140 | 1410 | 1720 | |
| | 10 | 7.5 | 0 | 0 | 0 | 0 | **250** | 390 | 490 | 600 | 750 | 930 | 1160 | 1430 | 1760 |
| | 15 | 11 | 0 | 0 | 0 | 0 | **170** | **270** | 340 | 430 | 530 | 660 | 820 | 1020 | 1260 |

**Table 11A**

| Motor Rating | | | 75° C Insulation - AWG Copper Wire Size | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 |
| 115 | 1/3 | .25 | 130 | 210 | 340 | 540 | 840 | 1300 | 1610 | 1960 | 2390 | 2910 | 3540 | 4210 | 5060 |
| | 1/2 | .37 | 100 | 160 | 250 | 390 | 620 | 960 | 1190 | 1460 | 1780 | 2160 | 2630 | 3140 | 3770 |
| 230 | 1/3 | .25 | 550 | 880 | 1390 | 2190 | 3400 | 5250 | 6520 | 7960 | 9690 | | | | |
| | 1/2 | .37 | 400 | 650 | 1020 | 1610 | 2510 | 3880 | 4810 | 5880 | 7170 | 8720 | | | |
| | 3/4 | .55 | 300 | 480 | 760 | 1200 | 1870 | 2890 | 3580 | 4370 | 5330 | 6470 | 7870 | 9380 | |
| | 1 | .75 | 250 | 400 | 630 | 990 | 1540 | 2380 | 2960 | 3610 | 4410 | 5360 | 6520 | 7780 | 9350 |
| | 1 1/2 | 1.1 | 190 | 310 | 480 | 770 | 1200 | 1870 | 2320 | 2850 | 3500 | 4280 | 5240 | 6300 | 7620 |
| | 2 | 1.5 | 150 | 250 | 390 | 620 | 970 | 1530 | 1910 | 2360 | 2930 | 3620 | 4480 | 5470 | 6700 |
| | 3 | 2.2 | **120** | 190 | 300 | 470 | 750 | 1190 | 1490 | 1850 | 2320 | 2890 | 3610 | 4470 | 5550 |
| | 5 | 3.7 | 0 | **110** | 180 | 280 | 450 | 710 | 890 | 1110 | 1390 | 1740 | 2170 | 2680 | 3330 |
| | 7 1/2 | 5.5 | 0 | 0 | **120** | 200 | 310 | 490 | 610 | 750 | 930 | 1140 | 1410 | 1720 | 2100 |
| | 10 | 7.5 | 0 | 0 | 0 | **160** | 250 | 390 | 490 | 600 | 750 | 930 | 1160 | 1430 | 1760 |
| | 15 | 11 | 0 | 0 | 0 | 0 | **170** | 270 | 340 | 430 | 530 | 660 | 820 | 1020 | 1260 |

1 Foot = .3048 Meter

Lengths **not** in bold type meet the U.S. National Electrical Code ampacity for either individual conductors or jacketed 60°C or 75°C cable.

Lengths in bold type meet the National Electric Code ampacity only for individual conductor 60°C or 75°C cable, in free air or water, not in magnetic enclosure or conduit. If any other cable is used, the National Electric Code as well as the local codes should be observed. Flat molded and web cable is considered jacketed cable.

Cable lengths in Table 11 & 11A allow for a 5% voltage drop running at maximum nameplate amperes. If 3% voltage drop is desired multiply Table 11 and 11A lengths by .6 to get maximum cable length.

Table 11 & 11A is based on copper wire. If aluminum wire is used, it must be two sizes larger than copper wire and oxidation inhibitors must be used on connections.

**EXAMPLE:** If Table 11 & 11A calls for #12 copper wire, #10 aluminum wire would be required.

The portion of the total cable length which is between the supply and single phase control box, with a line contactor, should not exceed 25% of total maximum allowable to ensure reliable contactor operation. Single phase control boxes without line contactors may be connected at any point in the total cable length.

Contact Franklin Electric for 90°C cable lengths. See pages 14, 42, and 43 for applications using 230V motors on 208V power systems.

## Two different cable sizes can be used.

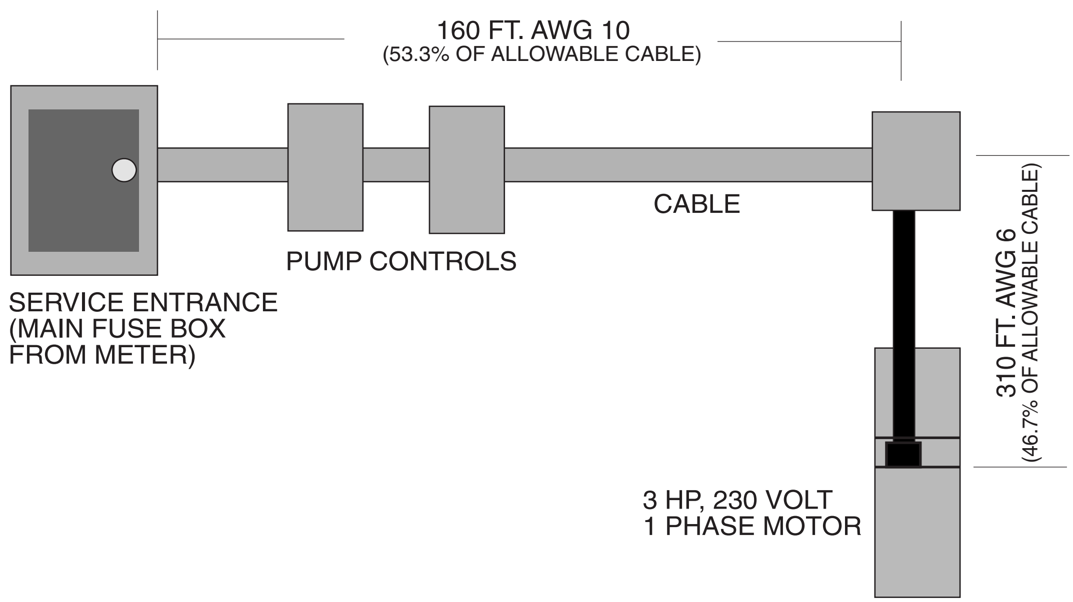
Depending on the installation, any number of combinations of cable may be used.

For example, in a replacement installation, the well already has 160 feet of buried #10 cable between the service entrance and the well head. The question is: What size cable is required in the well with a 3 HP, 230 volt, single phase motor setting at 310 feet?

1. From Table 11 & 11A, a 3 HP motor can use up to 300 feet of #10 AWG cable.
2. The application has 160 feet of buried #10 AWG cable.
3. 160 feet ÷ 300 feet (max allowable) is equal to 53.3% of max allowable.
4. 100% - 53.3% = 46.7% remaining of another size cable.
5. 310 feet (well head to motor) is 46.7% of max allowable length of another cable size.
6. 310 feet ÷ .467 (46.7%) = 664 feet is max allowable.
7. 664 feet is less than or equal to what size cable in Table 11 or 11A under the 3 HP listing?

   The table shows #8 is good for 470 feet, which is too short. #6 is good for 750 feet, therefore #6 can be used for the remaining 310 feet.

**EXAMPLE:** 3 HP, 230 Volt, 1 PH Motor



# Application - Single Phase Motors

## Table 13 Single Phase Motor Specifications (60 Hz) 3450 RPM

| Type | Motor Model Prefix | Rating | | | | | Full Load (2) Amps | Maximum (S.F. Load) (2) Amps | Winding (1) Res. In Ohms M=Main Res. S=Start Res. | Efficiency % | | | Power Factor % | | | Locked Rotor AMPS | KVA Code | Circuit Breakers or Fuse Amps | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HP | KW | Volts | Hz | S.F. | | | | S.F. | F.L. | 3/4 | S.F. | F.L. | 3/4 | | | Nontime Delay (Std.) Fuse | Dual Element Time Delay Fuse | Inverse Time Breaker |
| 4 Inch 2 - Wire | 244502 | 1/3 | 0.25 | 115 | 60 | 1.75 | 8.0 | 9.2 | 1.4-1.8 | 60 | 51 | 45 | 71 | 54 | 47 | 48.4 | S | 25 | 15 | 20 |
| | 244503 | 1/3 | 0.25 | 230 | 60 | 1.75 | 4.0 | 4.6 | 6.0-7.4 | 60 | 51 | 45 | 71 | 54 | 47 | 24.2 | S | 15 | 8 | 15 |
| | 244504 | 1/2 | 0.37 | 115 | 60 | 1.60 | 10.0 | 12.0 | 1.0-1.3 | 62 | 55 | 49 | 73 | 58 | 50 | 64.4 | R | 35 | 20 | 30 |
| | 244505 | 1/2 | 0.37 | 230 | 60 | 1.60 | 5.0 | 6.0 | 4.2-5.2 | 62 | 55 | 49 | 73 | 58 | 50 | 32.2 | R | 20 | 10 | 15 |
| | 244507 | 3/4 | 0.55 | 230 | 60 | 1.50 | 6.8 | 8.0 | 3.0-3.6 | 64 | 59 | 53 | 74 | 62 | 53 | 40.7 | N | 25 | 15 | 20 |
| | 244508 | 1 | 0.75 | 230 | 60 | 1.40 | 8.2 | 9.8 | 2.2-2.7 | 65 | 62 | 57 | 74 | 63 | 54 | 48.7 | N | 30 | 20 | 25 |
| | 244309 | 1 1/2 | 1.1 | 230 | 60 | 1.30 | 10.6 | 13.1 | 1.5-1.9 | 65 | 63 | 59 | 80 | 74 | 66 | 66.6 | M | 35 | 20 | 30 |
| 4 Inch 3 - Wire | 214502 | 1/3 | 0.25 | 115 | 60 | 1.75 | Y8.0<br>B8.0<br>R0 | Y9.2<br>B9.2<br>R0 | M1.4-1.8<br>S6.5-7.9 | 60 | 51 | 45 | 71 | 54 | 47 | 34.8 | N | 25 | 15 | 20 |
| | 214503 | 1/3 | 0.25 | 230 | 60 | 1.75 | Y4.0<br>B4.0<br>R0 | Y4.6<br>B4.6<br>R0 | M6.0-7.4<br>S26.1-32.0 | 60 | 51 | 45 | 71 | 54 | 47 | 17.2 | N | 15 | 8 | 15 |
| | 214504 | 1/2 | 0.37 | 115 | 60 | 1.60 | Y10.0<br>B10.0<br>R0 | Y12.0<br>B12.0<br>R0 | M1.0-1.3<br>S4.1-5.1 | 62 | 55 | 49 | 73 | 58 | 50 | 50.5 | M | 35 | 20 | 30 |
| | 214505 | 1/2 | 0.37 | 230 | 60 | 1.60 | Y5.0<br>B5.0<br>R0 | Y6.0<br>B6.0<br>R0 | M4.2-5.2<br>S16.7-20.5 | 62 | 55 | 49 | 73 | 58 | 50 | 23.0 | M | 20 | 10 | 15 |
| | 214507 | 3/4 | 0.55 | 230 | 60 | 1.50 | Y6.8<br>B6.8<br>R0 | Y8.0<br>B8.0<br>R0 | M3.0-3.6<br>S11.0-13.4 | 64 | 59 | 53 | 74 | 62 | 53 | 34.2 | M | 25 | 15 | 20 |
| | 214508 | 1 | 0.75 | 230 | 60 | 1.40 | Y8.2<br>B8.2<br>R0 | Y9.8<br>B9.8<br>R0 | M2.2-2.7<br>S10.1-12.3 | 65 | 62 | 57 | 74 | 63 | 54 | 41.8 | L | 30 | 20 | 25 |
| 4 Inch 3 - Wire with Run Cap | 224300 | 1 1/2 | 1.1 | 230 | 60 | 1.30 | Y10.0<br>B9.9<br>R1.3 | Y11.5<br>B11.0<br>R1.3 | M1.5-2.3<br>S6.2-12.0 | 68 | 66 | 62 | 81 | 74 | 66 | 52.0 | J | 35 | 20 | 30 |
| | 224301 | 2 | 1.5 | 230 | 60 | 1.25 | Y10.0<br>B9.3<br>R2.6 | Y13.2<br>B11.9<br>R2.6 | M1.6-2.3<br>S5.2-7.15 | 70 | 71 | 69 | 93 | 91 | 87 | 51.0 | G | 30 | 20 | 25 |
| | 224302 | 3 | 2.2 | 230 | 60 | 1.15 | Y14.0<br>B12.2<br>R4.7 | Y17.0<br>B14.5<br>R4.5 | M.9-1.5<br>S3.0-4.9 | 71 | 72 | 70 | 98 | 98 | 96 | 82.0 | G | 45 | 30 | 40 |
| | 224303 | 5 | 3.7 | 230 | 60 | 1.15 | Y23.0<br>B19.1<br>R8.0 | Y27.5<br>B23.2<br>R7.8 | M.68-1.0<br>S2.1-2.8 | 71 | 72 | 70 | 98 | 96 | 94 | 121.0 | F | 80 | 45 | 60 |
| 6 Inch | 226110 | 5 | 3.7 | 230 | 60 | 1.15 | Y23.0<br>B18.2<br>R8.0 | Y27.5<br>B23.2<br>R7.8 | M.55-.68<br>S1.3-1.6 | 76 | 75 | 72 | 98 | 98 | 99 | 99.0 | E | 80 | 45 | 60 |
| | 226111 | 7 1/2 | 5.5 | 230 | 60 | 1.15 | Y36.5<br>B34.4<br>R5.5 | Y42.1<br>B40.5<br>R5.4 | M.36-.50<br>S.92-1.2 | 73 | 74 | 74 | 91 | 90 | 87 | 165.0 | F | 125 | 70 | 100 |
| | 226112 | 10 | 7.5 | 230 | 60 | 1.15 | Y44.0<br>B39.5<br>R9.3 | Y51.0<br>B47.5<br>R8.9 | M.27-.33<br>S.80-.99 | 76 | 77 | 76 | 96 | 96 | 95 | 204.0 | E | 150 | 80 | 125 |
| | 226113 | 15 | 11 | 230 | 60 | 1.15 | Y62.0<br>B52.0<br>R17.5 | Y75.0<br>B62.5<br>R16.9 | M.17-.22<br>S.68-.93 | 79 | 80 | 80 | 97 | 98 | 98 | 303.0 | E | 200 | 125 | 175 |

(1) Main winding - yellow to black
Start winding - yellow to red

(2) Y = Yellow lead - line amps
B = Black lead - main winding amp
R = Red lead - start or auxiliary winding amps

**Performance is typical, not guaranteed, at specified voltages and specified capacitor values.**

**Performance at voltage ratings not shown is similar, except amps vary inversely with voltage.**

## Auxiliary Running Capacitors

Added capacitors must be connected across "Red" and "Black" control box terminals, in parallel with any existing running capacitors. The additional capacitor(s) should be mounted in an auxiliary box. The values of additional running capacitors most likely to reduce noise are given below. The tabulation gives the S.F. amps normally in each lead with the added capacitor.

**Table 14 Auxiliary Capacitor Sizing**

| Motor Rating | | Normal Running Capacitor(s) | Auxilary Running Capacitors For Noise Reduction | | | S.F. Amps with Run Cap | | |
|---|---|---|---|---|---|---|---|---|
| HP | Volts | Mfd. | Mfd | Min. Volts | Franklin Part | Yellow | Black | Red |
| 1/3 | 115 | 0 | 45(1) | 370 | One 155327109 | 6.3 | 5.3 | 2.9 |
| 1/2 | | 0 | 60(1) | 370 | Two 155327101 | 8.4 | 7.0 | 4.0 |
| 1/3 | 230 | 0 | 10(1) | 370 | One 155328102 | 3.3 | 3.1 | 1.2 |
| 1/2 | | 0 | 15(1) | 370 | One 155328101 | 4.2 | 3.5 | 2.0 |
| 3/4 | | 0 | 20(1) | 370 | One 155328103 | 5.8 | 5.0 | 2.5 |
| 1 | | 0 | 25(1) | 370 | One ea. 155328101 155328102 | 7.1 | 5.6 | 3.4 |
| 1 1/2 | | 10 | 20 | 370 | One 155328103 | 9.3 | 7.5 | 4.4 |
| 2 | | 20 | 10 | 370 | One 155328102 | 11.2 | 9.2 | 3.8 |
| 3 | | 35 | 10 | 370 | One 155328102 | 16.1 | 13.0 | 5.9 |
| 5 | | 60 | None | 370 | | 27.5 | 23.2 | 7.8 |
| 7 1/2 | | 45 | 45 | 370 | One ea. 155327101 155328101 | 37.0 | 32.0 | 11.3 |
| 10 | | 70 | 30 | 370 | One 155327101 | 49.0 | 42.0 | 13.0 |
| 15 | | 135 | None | | | 75.0 | 62.5 | 16.9 |

(1) Do not add running capacitors to standard production 1/3 through 1 HP control boxes, which use current relays, solid state starting switches or QD relays! Adding capacitors will cause switch failure. If the control box is converted to use a voltage relay, the specified running capacitance can be added.

## Buck-Boost Transformers

When the available power supply voltage is not within the proper range, a buck-boost transformer is often used to adjust voltage to match the motor. The most common usage on submersible motors is boosting a 208 volt supply to use a standard 230 volt single phase submersible motor and control. While tables to give a wide range of voltage boost or buck are published by transformer manufacturers, the following table shows Franklin's recommendations. The table, based on boosting the voltage 10%, shows the minimum rated transformer KVA needed and the common standard transformer KVA.

**Table 14A Buck-Boost Transformer Sizing**

| Motor HP | 1/3 | 1/2 | 3/4 | 1 | 1 1/2 | 2 | 3 | 5 | 7 1/2 | 10 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Load KVA | 1.02 | 1.36 | 1.84 | 2.21 | 2.65 | 3.04 | 3.91 | 6.33 | 9.66 | 11.70 | 16.60 |
| Minimum XFMR KVA | 0.11 | 0.14 | 0.19 | 0.22 | 0.27 | 0.31 | 0.40 | 0.64 | 0.97 | 1.20 | 1.70 |
| Standard XFMR KVA | 0.25 | 0.25 | 0.25 | 0.25 | 0.50 | 0.50 | 0.50 | 0.75 | 1.00 | 1.50 | 2.00 |

Buck-Boost transformers are power transformers, not control transformers. They may also be used to lower voltage when the available power supply voltage is too high.

## Table 15 Three Phase 60°C Cable, 60 Hz (Service Entrance to Motor) Maximum Length in Feet

| Motor Rating | | | 60°C Insulation - AWG Copper Wire Size | | | | | | | | | | | | | MCM Copper Wire Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 | 250 | 300 | 350 | 400 | 500 |
| | 1/2 | 0.37 | 710 | 1140 | 1800 | 2840 | 4420 | | | | | | | | | | | | | |
| 200 v | 3/4 | 0.55 | 510 | 810 | 1280 | 2030 | 3160 | | | | | | | | | | | | | |
| 60Hz | 1 | 0.75 | 430 | 690 | 1080 | 1710 | 2670 | 4140 | 5140 | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 310 | 500 | 790 | 1260 | 1960 | 3050 | 3780 | | | | | | | | | | | |
| Phase | 2 | 1.5 | 240 | 390 | 610 | 970 | 1520 | 2360 | 2940 | 3610 | 4430 | 5420 | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 180 | 290 | 470 | 740 | 1160 | 1810 | 2250 | 2760 | 3390 | 4130 | | | | | | | | |
| | 5 | 3.7 | **110** | 170 | 280 | 440 | 690 | 1080 | 1350 | 1660 | 2040 | 2490 | 3050 | 3670 | 4440 | 5030 | | | | |
| | 7 1/2 | 5.5 | 0 | 0 | 200 | 310 | 490 | 770 | 960 | 1180 | 1450 | 1770 | 2170 | 2600 | 3150 | 3560 | | | | |
| | 10 | 7.5 | 0 | 0 | 0 | **230** | 370 | 570 | 720 | 880 | 1090 | 1330 | 1640 | 1970 | 2390 | 2720 | 3100 | 3480 | 3800 | 4420 |
| | 15 | 11 | 0 | 0 | 0 | **160** | **250** | 390 | 490 | 600 | 740 | 910 | 1110 | 1340 | 1630 | 1850 | 2100 | 2350 | 2570 | 2980 |
| | 20 | 15 | 0 | 0 | 0 | 0 | **190** | **300** | 380 | 460 | 570 | 700 | 860 | 1050 | 1270 | 1440 | 1650 | 1850 | 2020 | 2360 |
| | 25 | 18.5 | 0 | 0 | 0 | 0 | 0 | **240** | **300** | **370** | 460 | 570 | 700 | 840 | 1030 | 1170 | 1330 | 1500 | 1640 | 1900 |
| | 30 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | **250** | **310** | **380** | 470 | 580 | 700 | 850 | 970 | 1110 | 1250 | 1360 | 1590 |
| | 1/2 | 0.37 | 930 | 1490 | 2350 | 3700 | 5760 | 8910 | | | | | | | | | | | | |
| 230V | 3/4 | 0.55 | 670 | 1080 | 1700 | 2580 | 4190 | 6490 | 8060 | 9860 | | | | | | | | | | |
| 60 Hz | 1 | 0.75 | 560 | 910 | 1430 | 2260 | 3520 | 5460 | 6780 | 8290 | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 420 | 670 | 1060 | 1670 | 2610 | 4050 | 5030 | 6160 | 7530 | 9170 | | | | | | | | |
| Phase | 2 | 1.5 | 320 | 510 | 810 | 1280 | 2010 | 3130 | 3890 | 4770 | 5860 | 7170 | 8780 | | | | | | | |
| 3 - Lead | 3 | 2.2 | 240 | 390 | 620 | 990 | 1540 | 2400 | 2980 | 3660 | 4480 | 5470 | 6690 | 8020 | 9680 | | | | | |
| | 5 | 3.7 | **140** | 230 | 370 | 590 | 920 | 1430 | 1790 | 2190 | 2690 | 3290 | 4030 | 4850 | 5870 | 6650 | 7560 | 8460 | 9220 | |
| | 7 1/2 | 5.5 | 0 | **160** | 260 | 420 | 650 | 1020 | 1270 | 1560 | 1920 | 2340 | 2870 | 3440 | 4160 | 4710 | 5340 | 5970 | 6500 | 7510 |
| | 10 | 7.5 | 0 | 0 | **190** | 310 | 490 | 760 | 950 | 1170 | 1440 | 1760 | 2160 | 2610 | 3160 | 3590 | 4100 | 4600 | 5020 | 5840 |
| | 15 | 11 | 0 | 0 | 0 | **210** | 330 | 520 | 650 | 800 | 980 | 1200 | 1470 | 1780 | 2150 | 2440 | 2780 | 3110 | 3400 | 3940 |
| | 20 | 15 | 0 | 0 | 0 | 0 | **250** | 400 | 500 | 610 | 760 | 930 | 1140 | 1380 | 1680 | 1910 | 2180 | 2450 | 2680 | 3120 |
| | 25 | 18.5 | 0 | 0 | 0 | 0 | 0 | **320** | 400 | 500 | 610 | 750 | 920 | 1120 | 1360 | 1540 | 1760 | 1980 | 2160 | 2520 |
| | 30 | 22 | 0 | 0 | 0 | 0 | 0 | **260** | **330** | **410** | 510 | 620 | 760 | 930 | 1130 | 1280 | 1470 | 1650 | 1800 | 2110 |
| | 1/2 | 0.37 | 2690 | 4290 | 6730 | | | | | | | | | | | | | | | |
| 380V | 3/4 | 0.55 | 2000 | 3190 | 5010 | 7860 | | | | | | | | | | | | | | |
| 60 Hz | 1 | 0.75 | 1620 | 2580 | 4060 | 6390 | 9980 | | | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 1230 | 1970 | 3100 | 4890 | 7630 | | | | | | | | | | | | | |
| Phase | 2 | 1.5 | 870 | 1390 | 2180 | 3450 | 5400 | 8380 | | | | | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 680 | 1090 | 1710 | 2690 | 4200 | 6500 | 8020 | 9830 | | | | | | | | | | |
| | 5 | 3.7 | 400 | 640 | 1010 | 1590 | 2490 | 3870 | 4780 | 5870 | 7230 | 8830 | | | | | | | | |
| | 7 1/2 | 5.5 | 270 | 440 | 690 | 1090 | 1710 | 2640 | 3260 | 4000 | 4930 | 6010 | 7290 | 8780 | | | | | | |
| | 10 | 7.5 | **200** | **320** | 510 | 800 | 1250 | 1930 | 2380 | 2910 | 3570 | 4330 | 5230 | 6260 | 7390 | 8280 | 9340 | | | |
| | 15 | 11 | 0 | 0 | **370** | 590 | 920 | 1430 | 1770 | 2170 | 2690 | 3290 | 4000 | 4840 | 5770 | 6520 | 7430 | 8250 | 8990 | |
| | 20 | 15 | 0 | 0 | 0 | **440** | 700 | 1090 | 1350 | 1670 | 2060 | 2530 | 3090 | 3760 | 4500 | 5110 | 5840 | 6510 | 7120 | 8190 |
| | 25 | 18.5 | 0 | 0 | 0 | **360** | 570 | 880 | 1100 | 1350 | 1670 | 2050 | 2510 | 3040 | 3640 | 4130 | 4720 | 5250 | 5740 | 6590 |
| | 30 | 22 | 0 | 0 | 0 | 0 | **470** | 730 | 910 | 1120 | 1380 | 1700 | 2080 | 2520 | 3020 | 3430 | 3920 | 4360 | 4770 | 5490 |
| | 40 | 30 | 0 | 0 | 0 | 0 | 0 | **530** | 660 | 820 | 1010 | 1240 | 1520 | 1840 | 2200 | 2500 | 2850 | 3170 | 3470 | 3990 |
| | 50 | 37 | 0 | 0 | 0 | 0 | 0 | 0 | **540** | **660** | 820 | 1000 | 1220 | 1480 | 1770 | 2010 | 2290 | 2550 | 2780 | 3190 |
| | 60 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **560** | **690** | 850 | 1030 | 1250 | 1500 | 1700 | 1940 | 2150 | 2350 | 2700 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **570** | **700** | **860** | 1050 | 1270 | 1440 | 1660 | 1850 | 2030 | 2350 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **510** | **630** | **760** | 910 | 1030 | 1180 | 1310 | 1430 | 1650 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **620** | **740** | **840** | **950** | 1060 | 1160 | 1330 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **620** | **700** | **790** | **880** | **960** | 1090 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **650** | **750** | **840** | **920** | 1070 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **630** | **700** | **760** | **880** |

Continued on page 16

## Table 16  Three Phase 60°C Cable (Continued)

| Motor Rating | | | 60°C Insulation - AWG Copper Wire Size | | | | | | | | | | | | | MCM Copper Wire Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 | 250 | 300 | 350 | 400 | 500 |
| | 1/2 | 0.37 | 3770 | 6020 | 9460 | | | | | | | | | | | | | | | |
| 460V | 3/4 | 0.55 | 2730 | 4350 | 6850 | | | | | | | | | | | | | | | |
| 60Hz | 1 | 0.75 | 2300 | 3670 | 5770 | 9070 | | | | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 1700 | 2710 | 4270 | 6730 | | | | | | | | | | | | | | |
| Phase | 2 | 1.5 | 1300 | 2070 | 3270 | 5150 | 8050 | | | | | | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 1000 | 1600 | 2520 | 3970 | 6200 | | | | | | | | | | | | | |
| | 5 | 3.7 | 590 | 950 | 1500 | 2360 | 3700 | 5750 | | | | | | | | | | | | |
| | 7 1/2 | 5.5 | 420 | 680 | 1070 | 1690 | 2640 | 4100 | 5100 | 6260 | 7680 | | | | | | | | | |
| | 10 | 7.5 | 310 | 500 | 790 | 1250 | 1960 | 3050 | 3800 | 4680 | 5750 | 7050 | | | | | | | | |
| | 15 | 11 | 0 | **340** | 540 | 850 | 1340 | 2090 | 2600 | 3200 | 3930 | 4810 | 5900 | 7110 | | | | | | |
| | 20 | 15 | 0 | 0 | **410** | 650 | 1030 | 1610 | 2000 | 2470 | 3040 | 3730 | 4580 | 5530 | | | | | | |
| | 25 | 18.5 | 0 | 0 | 0 | **530** | 830 | 1300 | 1620 | 1990 | 2450 | 3010 | 3700 | 4470 | 5430 | | | | | |
| | 30 | 22 | 0 | 0 | 0 | **430** | 680 | 1070 | 1330 | 1640 | 2030 | 2490 | 3060 | 3700 | 4500 | 5130 | 5860 | | | |
| | 40 | 30 | 0 | 0 | 0 | 0 | **500** | 790 | 980 | 1210 | 1490 | 1830 | 2250 | 2710 | 3290 | 3730 | 4250 | | | |
| | 50 | 37 | 0 | 0 | 0 | 0 | 0 | **640** | 800 | 980 | 1210 | 1480 | 1810 | 2190 | 2650 | 3010 | 3420 | 3830 | 4180 | 4850 |
| | 60 | 45 | 0 | 0 | 0 | 0 | 0 | **540** | **670** | **830** | 1020 | 1250 | 1540 | 1850 | 2240 | 2540 | 2890 | 3240 | 3540 | 4100 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **680** | **840** | 1030 | 1260 | 1520 | 1850 | 2100 | 2400 | 2700 | 2950 | 3440 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **620** | **760** | **940** | 1130 | 1380 | 1560 | 1790 | 2010 | 2190 | 2550 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **740** | **890** | **1000** | 1220 | 1390 | 1560 | 1700 | 1960 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **760** | **920** | **1050** | **1190** | 1340 | 1460 | 1690 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **810** | **930** | **1060** | **1190** | 1300 | 1510 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **810** | **920** | **1030** | **1130** | 1310 |
| | 1/2 | 0.37 | 5900 | 9410 | | | | | | | | | | | | | | | | |
| 575V | 3/4 | 0.55 | 4270 | 6810 | | | | | | | | | | | | | | | | |
| 60 Hz | 1 | 0.75 | 3630 | 5800 | 9120 | | | | | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 2620 | 4180 | 6580 | | | | | | | | | | | | | | | |
| Phase | 2 | 1.5 | 2030 | 3250 | 5110 | 8060 | | | | | | | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 1580 | 2530 | 3980 | 6270 | | | | | | | | | | | | | | |
| | 5 | 3.7 | 920 | 1480 | 2330 | 3680 | 5750 | | | | | | | | | | | | | |
| | 7 1/2 | 5.5 | 660 | 1060 | 1680 | 2650 | 4150 | | | | | | | | | | | | | |
| | 10 | 7.5 | 490 | 780 | 1240 | 1950 | 3060 | 4770 | 5940 | | | | | | | | | | | |
| | 15 | 11 | **330** | 530 | 850 | 1340 | 2090 | 3260 | 4060 | | | | | | | | | | | |
| | 20 | 15 | 0 | **410** | 650 | 1030 | 1610 | 2520 | 3140 | 3860 | 4760 | 5830 | | | | | | | | |
| | 25 | 19 | 0 | 0 | **520** | 830 | 1300 | 2030 | 2530 | 3110 | 3840 | 4710 | | | | | | | | |
| | 30 | 22 | 0 | 0 | **430** | 680 | 1070 | 1670 | 2080 | 2560 | 3160 | 3880 | 4770 | 5780 | 7030 | 8000 | | | | |
| | 40 | 30 | 0 | 0 | 0 | **500** | 790 | 1240 | 1540 | 1900 | 2330 | 2860 | 3510 | 4230 | 5140 | 5830 | | | | |
| | 50 | 37 | 0 | 0 | 0 | 0 | **640** | 1000 | 1250 | 1540 | 1890 | 2310 | 2840 | 3420 | 4140 | 4700 | 5340 | 5990 | 6530 | 7580 |
| | 60 | 45 | 0 | 0 | 0 | 0 | 0 | **850** | 1060 | 1300 | 1600 | 1960 | 2400 | 2890 | 3500 | 3970 | 4520 | 5070 | 5530 | 6410 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | **690** | **860** | **1060** | 1310 | 1600 | 1970 | 2380 | 2890 | 3290 | 3750 | 5220 | 4610 | 5370 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **790** | **970** | **1190** | 1460 | 1770 | 2150 | 2440 | 2790 | 3140 | 3430 | 3990 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **770** | **950** | **1160** | 1400 | 1690 | 1920 | 2180 | 2440 | 2650 | 3070 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **800** | **990** | **1190** | 1440 | 1630 | 1860 | 2080 | 2270 | 2640 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **870** | **1050** | **1270** | **1450** | 1650 | 1860 | 2030 | 2360 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **920** | **1110** | **1260** | **1440** | 1620 | 1760 | 2050 |

See Footnotes on Page 11 for information on bold figures.

## Table 17 Three Phase 60°C Cable (Continued)

| Motor Rating | | | 60°C Insulation - AWG Copper Wire Size | | | | | | | | | | | | | MCM Copper Wire Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 | 250 | 300 | 350 | 400 | 500 |
| 200V | 5 | 3.7 | 160 | 250 | 420 | 660 | 1030 | 1620 | 2020 | 2490 | 3060 | 3730 | 4570 | 5500 | 6660 | 7540 | | | | |
| 60Hz | 7 1/2 | 5.5 | 110 | 180 | 300 | 460 | 730 | 1150 | 1440 | 1770 | 2170 | 2650 | 3250 | 3900 | 4720 | 5340 | | | | |
| Three | 10 | 7.5 | **80** | 130 | 210 | 340 | 550 | 850 | 1080 | 1320 | 1630 | 1990 | 2460 | 2950 | 3580 | 4080 | 4650 | 5220 | 5700 | 6630 |
| Phase | 15 | 11 | 0 | 0 | **140** | 240 | 370 | 580 | 730 | 900 | 1110 | 1360 | 1660 | 2010 | 2440 | 2770 | 3150 | 3520 | 3850 | 4470 |
| 6 - Lead | 20 | 15 | 0 | 0 | 0 | **170** | 280 | 450 | 570 | 690 | 850 | 1050 | 1290 | 1570 | 1900 | 2160 | 2470 | 2770 | 3030 | 3540 |
| Y-D | 25 | 18.5 | 0 | 0 | 0 | **140** | **220** | 360 | 450 | 550 | 690 | 850 | 1050 | 1260 | 1540 | 1750 | 1990 | 2250 | 2460 | 2850 |
| | 30 | 22 | 0 | 0 | 0 | 0 | **180** | 294 | 370 | 460 | 570 | 700 | 870 | 1050 | 1270 | 1450 | 1660 | 1870 | 2040 | 2380 |
| 230V | 5 | 3.7 | 210 | 340 | 550 | 880 | 1380 | 2140 | 2680 | 3280 | 4030 | 4930 | 6040 | 7270 | 8800 | 9970 | | | | |
| 60Hz | 7 1/2 | 5.5 | 150 | 240 | 390 | 630 | 970 | 1530 | 1900 | 2340 | 2880 | 3510 | 4300 | 5160 | 6240 | 7060 | 8010 | 8950 | 9750 | |
| Three | 10 | 7.5 | **110** | 180 | 280 | 460 | 730 | 1140 | 1420 | 1750 | 2160 | 2640 | 3240 | 3910 | 4740 | 5380 | 6150 | 6900 | 7530 | 8760 |
| Phase | 15 | 11 | 0 | 0 | **190** | 310 | 490 | 780 | 970 | 1200 | 1470 | 1800 | 2200 | 2670 | 3220 | 3660 | 4170 | 4660 | 5100 | 5910 |
| 6 - Lead | 20 | 15 | 0 | 0 | **140** | 230 | 370 | 600 | 750 | 910 | 1140 | 1390 | 1710 | 2070 | 2520 | 2860 | 3270 | 3670 | 4020 | 4680 |
| Y-D | 25 | 18.5 | 0 | 0 | 0 | **190** | 300 | 480 | 600 | 750 | 910 | 1120 | 1380 | 1680 | 2040 | 2310 | 2640 | 2970 | 3240 | 3780 |
| | 30 | 22 | 0 | 0 | 0 | **150** | **240** | 390 | 490 | 610 | 760 | 930 | 1140 | 1390 | 1690 | 1920 | 2200 | 2470 | 2700 | 3160 |
| 380V | 5 | 3.7 | 600 | 960 | 1510 | 2380 | 3730 | 5800 | 7170 | 8800 | | | | | | | | | | |
| 60Hz | 7 1/2 | 5.5 | 400 | 660 | 1030 | 1630 | 2560 | 3960 | 4890 | 6000 | 7390 | 9010 | | | | | | | | |
| Three | 10 | 7.5 | 300 | 480 | 760 | 1200 | 1870 | 2890 | 3570 | 4360 | 5350 | 6490 | 7840 | 9390 | | | | | | |
| Phase | 15 | 11 | 210 | 340 | 550 | 880 | 1380 | 2140 | 2650 | 3250 | 4030 | 4930 | 6000 | 7260 | 8650 | 9780 | | | | |
| 6 - Lead | 20 | 15 | **160** | 260 | 410 | 660 | 1050 | 1630 | 2020 | 2500 | 3090 | 3790 | 4630 | 5640 | 6750 | 7660 | 4260 | 9760 | | |
| Y-D | 25 | 18.5 | 0 | **210** | 330 | 540 | 850 | 1320 | 1650 | 2020 | 2500 | 3070 | 3760 | 4560 | 5460 | 6190 | 7080 | 7870 | 8610 | 9880 |
| | 30 | 22 | 0 | 0 | **270** | 430 | 700 | 1090 | 1360 | 1680 | 2070 | 2550 | 3120 | 3780 | 4530 | 5140 | 5880 | 6540 | 7150 | 8230 |
| | 40 | 30 | 0 | 0 | 0 | **320** | 510 | 790 | 990 | 1230 | 1510 | 1860 | 2280 | 2760 | 3300 | 3750 | 4270 | 4750 | 5200 | 5980 |
| | 50 | 37 | 0 | 0 | 0 | **250** | **400** | 630 | 810 | 990 | 1230 | 1500 | 1830 | 2220 | 2650 | 3010 | 3430 | 3820 | 4170 | 4780 |
| | 60 | 45 | 0 | 0 | 0 | 0 | **340** | 540 | 660 | 840 | 1030 | 1270 | 1540 | 1870 | 2250 | 2550 | 2910 | 3220 | 3520 | 4050 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | **450** | 550 | 690 | 855 | 1050 | 1290 | 1570 | 1900 | 2160 | 2490 | 2770 | 3040 | 3520 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | **420** | **520** | 640 | 760 | 940 | 1140 | 1360 | 1540 | 1770 | 1960 | 2140 | 2470 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **400** | **490** | **600** | 730 | 930 | 1110 | 1260 | 1420 | 1590 | 1740 | 1990 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **420** | **510** | **620** | 750 | 930 | 1050 | 1180 | 1320 | 1440 | 1630 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **360** | **440** | **540** | 660 | 780 | 970 | 1120 | 1260 | 1380 | 1600 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **480** | **580** | **690** | 790 | 940 | 1050 | 1140 | 1320 |
| 460V | 5 | 3.7 | 880 | 1420 | 2250 | 3540 | 5550 | 8620 | | | | | | | | | | | | |
| 60Hz | 7 1/2 | 5.5 | 630 | 1020 | 1600 | 2530 | 3960 | 6150 | 7650 | 9390 | | | | | | | | | | |
| Three | 10 | 7.5 | 460 | 750 | 1180 | 1870 | 2940 | 4570 | 5700 | 7020 | 8620 | | | | | | | | | |
| Phase | 15 | 11 | 310 | 510 | 810 | 1270 | 2010 | 3130 | 3900 | 4800 | 5890 | 7210 | 8850 | | | | | | | |
| 6 - Lead | 20 | 15 | **230** | 380 | 610 | 970 | 1540 | 2410 | 3000 | 3700 | 4560 | 5590 | 6870 | 8290 | | | | | | |
| Y-D | 25 | 18.5 | **190** | 310 | 490 | 790 | 1240 | 1950 | 2430 | 2980 | 3670 | 4510 | 5550 | 6700 | 8140 | | | | | |
| | 30 | 22 | 0 | **250** | 410 | 640 | 1020 | 1600 | 1990 | 2460 | 3040 | 3730 | 4590 | 5550 | 6750 | 7690 | 8790 | | | |
| | 40 | 30 | 0 | 0 | **300** | 480 | 750 | 1180 | 1470 | 1810 | 2230 | 2740 | 3370 | 4060 | 4930 | 5590 | 6370 | | | |
| | 50 | 37 | 0 | 0 | 0 | **370** | 590 | 960 | 1200 | 1470 | 1810 | 2220 | 2710 | 3280 | 3970 | 4510 | 5130 | 5740 | 6270 | 7270 |
| | 60 | 45 | 0 | 0 | 0 | **320** | **500** | 810 | 1000 | 1240 | 1530 | 1870 | 2310 | 2770 | 3360 | 3810 | 4330 | 4860 | 5310 | 6150 |
| | 75 | 55 | 0 | 0 | 0 | 0 | **420** | 660 | 810 | 1020 | 1260 | 1540 | 1890 | 2280 | 2770 | 3150 | 3600 | 4050 | 4420 | 5160 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | **500** | **610** | 760 | 930 | 1140 | 1410 | 1690 | 2070 | 2340 | 2680 | 3010 | 3280 | 3820 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | **470** | **590** | **730** | 880 | 1110 | 1330 | 1500 | 1830 | 2080 | 2340 | 2550 | 2940 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **510** | **630** | **770** | 950 | 1140 | 1380 | 1570 | 1790 | 2000 | 2180 | 2530 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **550** | **680** | **830** | 1000 | 1220 | 1390 | 1580 | 1780 | 1950 | 2270 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **590** | **730** | **880** | 1070 | 1210 | 1380 | 1550 | 1690 | 1970 |
| 575V | 5 | 3.7 | 1380 | 2220 | 3490 | 5520 | 8620 | | | | | | | | | | | | | |
| 60Hz | 7 1/2 | 5.5 | 990 | 1590 | 2520 | 3970 | 6220 | | | | | | | | | | | | | |
| Three | 10 | 7.5 | 730 | 1170 | 1860 | 2920 | 4590 | 7150 | 8910 | | | | | | | | | | | |
| Phase | 15 | 11 | 490 | 790 | 1270 | 2010 | 3130 | 4890 | 6090 | | | | | | | | | | | |
| 6 - Lead | 20 | 15 | 370 | 610 | 970 | 1540 | 2410 | 3780 | 4710 | 5790 | 7140 | 8740 | | | | | | | | |
| Y-D | 25 | 18.5 | **300** | 490 | 780 | 1240 | 1950 | 3040 | 3790 | 4660 | 5760 | 7060 | | | | | | | | |
| | 30 | 22 | **240** | 400 | 645 | 1020 | 1600 | 2500 | 3120 | 3840 | 4740 | 5820 | 7150 | 8670 | | | | | | |
| | 40 | 30 | 0 | **300** | 480 | 750 | 1180 | 1860 | 2310 | 2850 | 3490 | 4290 | 5260 | 6340 | 7710 | 8740 | | | | |
| | 50 | 37 | 0 | 0 | **380** | 590 | 960 | 1500 | 1870 | 2310 | 2830 | 3460 | 4260 | 5130 | 6210 | 7050 | 8010 | 8980 | 9790 | |
| | 60 | 45 | 0 | 0 | 0 | **500** | **790** | 1270 | 1590 | 1950 | 2400 | 2940 | 3600 | 4330 | 5250 | 5950 | 6780 | 7600 | 8290 | 9610 |
| | 75 | 55 | 0 | 0 | 0 | **420** | **660** | 1030 | 1290 | 1590 | 1960 | 2400 | 2950 | 3570 | 4330 | 4930 | 5620 | 6330 | 6910 | 8050 |
| | 100 | 75 | 0 | 0 | 0 | 0 | **400** | **780** | 960 | 1180 | 1450 | 1780 | 2190 | 2650 | 3220 | 3660 | 4180 | 4710 | 5140 | 5980 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | **600** | **740** | 920 | 1150 | 1420 | 1740 | 2100 | 2530 | 2880 | 3270 | 3660 | 3970 | 4600 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | **650** | **800** | **990** | 1210 | 1480 | 1780 | 2160 | 2450 | 2790 | 3120 | 3410 | 3950 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **700** | **860** | 1060 | 1300 | 1570 | 1910 | 2170 | 2480 | 2780 | 3040 | 3540 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **760** | **930** | 1140 | 1370 | 1670 | 1890 | 2160 | 2420 | 2640 | 3070 |

See Footnotes on Page 11 for information on bold figures.

**Table 18 Three Phase 75°C Cable, 60 Hz (Service Entrance to Motor) Maximum Length in Feet**

| Motor Rating | | | 75°C Insulation - AWG Copper Wire Size | | | | | | | | | | | | | MCM Copper Wire Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 | 250 | 300 | 350 | 400 | 500 |
| | 1/2 | 0.37 | 710 | 1140 | 1800 | 2840 | 4420 | | | | | | | | | | | | | |
| 200 v | 3/4 | 0.55 | 510 | 810 | 1280 | 2030 | 3160 | | | | | | | | | | | | | |
| 60Hz | 1 | 0.75 | 430 | 690 | 1080 | 1710 | 2670 | 4140 | 5140 | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 310 | 500 | 790 | 1260 | 1960 | 3050 | 3780 | | | | | | | | | | | |
| Phase | 2 | 1.5 | 240 | 390 | 610 | 970 | 1520 | 2360 | 2940 | 3610 | 4430 | 5420 | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 180 | 290 | 470 | 740 | 1160 | 1810 | 2250 | 2760 | 3390 | 4130 | | | | | | | | |
| | 5 | 3.7 | **110** | 170 | 280 | 440 | 690 | 1080 | 1350 | 1660 | 2040 | 2490 | 3050 | 3670 | 4440 | 5030 | | | | |
| | 7 1/2 | 5.5 | 0 | 0 | 200 | 310 | 490 | 770 | 960 | 1180 | 1450 | 1770 | 2170 | 2600 | 3150 | 3560 | | | | |
| | 10 | 7.5 | 0 | 0 | **150** | 230 | 370 | 570 | 720 | 880 | 1090 | 1330 | 1640 | 1970 | 2390 | 2720 | 3100 | 3480 | 3800 | 4420 |
| | 15 | 11 | 0 | 0 | 0 | **160** | 250 | 390 | 490 | 600 | 740 | 910 | 1110 | 1340 | 1630 | 1850 | 2100 | 2350 | 2570 | 2980 |
| | 20 | 15 | 0 | 0 | 0 | 0 | **190** | 300 | 380 | 460 | 570 | 700 | 860 | 1050 | 1270 | 1440 | 1650 | 1850 | 2020 | 2360 |
| | 25 | 18.5 | 0 | 0 | 0 | 0 | 0 | **240** | 300 | 370 | 460 | 570 | 700 | 840 | 1030 | 1170 | 1330 | 1500 | 1640 | 1900 |
| | 30 | 22 | 0 | 0 | 0 | 0 | 0 | **200** | **250** | 310 | 380 | 470 | 580 | 700 | 850 | 970 | 1110 | 1250 | 1360 | 1590 |
| | 1/2 | 0.37 | 930 | 1490 | 2350 | 3700 | 5760 | 8910 | | | | | | | | | | | | |
| 230V | 3/4 | 0.55 | 670 | 1080 | 1700 | 2580 | 4190 | 6490 | 8060 | 9860 | | | | | | | | | | |
| 60 Hz | 1 | 0.75 | 560 | 910 | 1430 | 2260 | 3520 | 5460 | 6780 | 8290 | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 420 | 670 | 1060 | 1670 | 2610 | 4050 | 5030 | 6160 | 7530 | 9170 | | | | | | | | |
| Phase | 2 | 1.5 | 320 | 510 | 810 | 1280 | 2010 | 3130 | 3890 | 4770 | 5860 | 7170 | 8780 | | | | | | | |
| 3 - Lead | 3 | 2.2 | 240 | 390 | 620 | 990 | 1540 | 2400 | 2980 | 3660 | 4480 | 5470 | 6690 | 8020 | 9680 | | | | | |
| | 5 | 3.7 | **140** | 230 | 370 | 590 | 920 | 1430 | 1790 | 2190 | 2690 | 3290 | 4030 | 4850 | 5870 | 6650 | 7560 | 8460 | 9220 | |
| | 7 1/2 | 5.5 | 0 | **160** | 260 | 420 | 650 | 1020 | 1270 | 1560 | 1920 | 2340 | 2870 | 3440 | 4160 | 4710 | 5340 | 5970 | 6500 | 7510 |
| | 10 | 7.5 | 0 | 0 | **190** | 310 | 490 | 760 | 950 | 1170 | 1440 | 1760 | 2160 | 2610 | 3160 | 3590 | 4100 | 4600 | 5020 | 5840 |
| | 15 | 11 | 0 | 0 | 0 | **210** | 330 | 520 | 650 | 800 | 980 | 1200 | 1470 | 1780 | 2150 | 2440 | 2780 | 3110 | 3400 | 3940 |
| | 20 | 15 | 0 | 0 | 0 | **160** | **250** | 400 | 500 | 610 | 760 | 930 | 1140 | 1380 | 1680 | 1910 | 2180 | 2450 | 2680 | 3120 |
| | 25 | 18.5 | 0 | 0 | 0 | 0 | **200** | 320 | 400 | 500 | 610 | 750 | 920 | 1120 | 1360 | 1540 | 1760 | 1980 | 2160 | 2520 |
| | 30 | 22 | 0 | 0 | 0 | 0 | 0 | **260** | 330 | 410 | 510 | 620 | 760 | 930 | 1130 | 1280 | 1470 | 1650 | 1800 | 2110 |
| | 1/2 | 0.37 | 2690 | 4290 | 6730 | | | | | | | | | | | | | | | |
| 380V | 3/4 | 0.55 | 2000 | 3190 | 5010 | 7860 | | | | | | | | | | | | | | |
| 60 Hz | 1 | 0.75 | 1620 | 2580 | 4060 | 6390 | 9980 | | | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 1230 | 1970 | 3100 | 4890 | 7630 | | | | | | | | | | | | | |
| Phase | 2 | 1.5 | 870 | 1390 | 2180 | 3450 | 5400 | 8380 | | | | | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 680 | 1090 | 1710 | 2690 | 4200 | 6500 | 8020 | 9830 | | | | | | | | | | |
| | 5 | 3.7 | 400 | 640 | 1010 | 1590 | 2490 | 3870 | 4780 | 5870 | 7230 | 8830 | | | | | | | | |
| | 7 1/2 | 5.5 | 270 | 440 | 690 | 1090 | 1710 | 2640 | 3260 | 4000 | 4930 | 6010 | 7290 | 8780 | | | | | | |
| | 10 | 7.5 | **200** | 320 | 510 | 800 | 1250 | 1930 | 2380 | 2910 | 3570 | 4330 | 5230 | 6260 | 7390 | 8280 | 9340 | | | |
| | 15 | 11 | 0 | 0 | 370 | 590 | 920 | 1430 | 1770 | 2170 | 2690 | 3290 | 4000 | 4840 | 5770 | 6520 | 7430 | 8250 | 8990 | |
| | 20 | 15 | 0 | 0 | **280** | 440 | 700 | 1090 | 1350 | 1670 | 2060 | 2530 | 3090 | 3760 | 4500 | 5110 | 5840 | 6510 | 7120 | 8190 |
| | 25 | 18.5 | 0 | 0 | 0 | **360** | 570 | 880 | 1100 | 1350 | 1670 | 2050 | 2510 | 3040 | 3640 | 4130 | 4720 | 5250 | 5740 | 6590 |
| | 30 | 22 | 0 | 0 | 0 | **290** | 470 | 730 | 910 | 1120 | 1380 | 1700 | 2080 | 2520 | 3020 | 3430 | 3920 | 4360 | 4770 | 5490 |
| | 40 | 30 | 0 | 0 | 0 | 0 | 0 | **530** | 660 | 820 | 1010 | 1240 | 1520 | 1840 | 2200 | 2500 | 2850 | 3170 | 3470 | 3990 |
| | 50 | 37 | 0 | 0 | 0 | 0 | 0 | **440** | **540** | 660 | 820 | 1000 | 1220 | 1480 | 1770 | 2010 | 2290 | 2550 | 2780 | 3190 |
| | 60 | 45 | 0 | 0 | 0 | 0 | 0 | **370** | **460** | **560** | 690 | 850 | 1030 | 1250 | 1500 | 1700 | 1940 | 2150 | 2350 | 2700 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **460** | **570** | 700 | 860 | 1050 | 1270 | 1440 | 1660 | 1850 | 2030 | 2350 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **420** | **510** | **630** | 760 | 910 | 1030 | 1180 | 1310 | 1430 | 1650 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **510** | **620** | **740** | 840 | 950 | 1060 | 1160 | 1330 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **520** | **620** | **700** | **790** | 880 | 960 | 1090 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **560** | **650** | **750** | **840** | 920 | 1070 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **550** | **630** | **700** | **760** | 880 |

Continued on page 19

### Table 19 Three Phase 75°C Cable (Continued)

| Motor Rating | | | 75°C Insulation - AWG Copper Wire Size | | | | | | | | | | | | | MCM Copper Wire Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 | 250 | 300 | 350 | 400 | 500 |
| | 1/2 | 0.37 | 3770 | 6020 | 9460 | | | | | | | | | | | | | | | |
| 460V | 3/4 | 0.55 | 2730 | 4350 | 6850 | | | | | | | | | | | | | | | |
| 60Hz | 1 | 0.75 | 2300 | 3670 | 5770 | 9070 | | | | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 1700 | 2710 | 4270 | 6730 | | | | | | | | | | | | | | |
| Phase | 2 | 1.5 | 1300 | 2070 | 3270 | 5150 | 8050 | | | | | | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 1000 | 1600 | 2520 | 3970 | 6200 | | | | | | | | | | | | | |
| | 5 | 3.7 | 590 | 950 | 1500 | 2360 | 3700 | 5750 | | | | | | | | | | | | |
| | 7 1/2 | 5.5 | 420 | 680 | 1070 | 1690 | 2640 | 4100 | 5100 | 6260 | 7680 | | | | | | | | | |
| | 10 | 7.5 | 310 | 500 | 790 | 1250 | 1960 | 3050 | 3800 | 4680 | 5750 | 7050 | | | | | | | | |
| | 15 | 11 | 0 | **340** | 540 | 850 | 1340 | 2090 | 2600 | 3200 | 3930 | 4810 | 5900 | 7110 | | | | | | |
| | 20 | 15 | 0 | 0 | 410 | 650 | 1030 | 1610 | 2000 | 2470 | 3040 | 3730 | 4580 | 5530 | | | | | | |
| | 25 | 18.5 | 0 | 0 | **330** | 530 | 830 | 1300 | 1620 | 1990 | 2450 | 3010 | 3700 | 4470 | 5430 | | | | | |
| | 30 | 22 | 0 | 0 | **270** | 430 | 680 | 1070 | 1330 | 1640 | 2030 | 2490 | 3060 | 3700 | 4500 | 5130 | 5860 | | | |
| | 40 | 30 | 0 | 0 | 0 | **320** | **500** | 790 | 980 | 1210 | 1490 | 1830 | 2250 | 2710 | 3290 | 3730 | 4250 | | | |
| | 50 | 37 | 0 | 0 | 0 | 0 | **410** | 640 | 800 | 980 | 1210 | 1480 | 1810 | 2190 | 2650 | 3010 | 3420 | 3830 | 4180 | 4850 |
| | 60 | 45 | 0 | 0 | 0 | 0 | 0 | **540** | **670** | 830 | 1020 | 1250 | 1540 | 1850 | 2240 | 2540 | 2890 | 3240 | 3540 | 4100 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | **440** | **550** | **680** | 840 | 1030 | 1260 | 1520 | 1850 | 2100 | 2400 | 2700 | 2950 | 3440 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **500** | **620** | **760** | 940 | 1130 | 1380 | 1560 | 1790 | 2010 | 2190 | 2550 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **600** | **740** | **890** | 1000 | 1220 | 1390 | 1560 | 1700 | 1960 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **630** | **760** | **920** | 1050 | 1190 | 1340 | 1460 | 1690 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **370** | **810** | **930** | 1060 | 1190 | 1300 | 1510 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **590** | **710** | **810** | **920** | 1030 | 1130 | 1310 |
| | 1/2 | 0.37 | 5900 | 9410 | | | | | | | | | | | | | | | | |
| 575V | 3/4 | 0.55 | 4270 | 6810 | | | | | | | | | | | | | | | | |
| 60 Hz | 1 | 0.75 | 3630 | 5800 | 9120 | | | | | | | | | | | | | | | |
| Three | 1 1/2 | 1.1 | 2620 | 4180 | 6580 | | | | | | | | | | | | | | | |
| Phase | 2 | 1.5 | 2030 | 3250 | 5110 | 8060 | | | | | | | | | | | | | | |
| 3 - Lead | 3 | 2.2 | 1580 | 2530 | 3980 | 6270 | | | | | | | | | | | | | | |
| | 5 | 3.7 | 920 | 1480 | 2330 | 3680 | 5750 | | | | | | | | | | | | | |
| | 7 1/2 | 5.5 | 660 | 1060 | 1680 | 2650 | 4150 | | | | | | | | | | | | | |
| | 10 | 7.5 | 490 | 780 | 1240 | 1950 | 3060 | 4770 | 5940 | | | | | | | | | | | |
| | 15 | 11 | **330** | 530 | 850 | 1340 | 2090 | 3260 | 4060 | | | | | | | | | | | |
| | 20 | 15 | 0 | **410** | 650 | 1030 | 1610 | 2520 | 3140 | 3860 | 4760 | 5830 | | | | | | | | |
| | 25 | 19 | 0 | 0 | 520 | 830 | 1300 | 2030 | 2530 | 3110 | 3840 | 4710 | | | | | | | | |
| | 30 | 22 | 0 | 0 | **430** | 680 | 1070 | 1670 | 2080 | 2560 | 3160 | 3880 | 4770 | 5780 | 7030 | 8000 | | | | |
| | 40 | 30 | 0 | 0 | 0 | **500** | 790 | 1240 | 1540 | 1900 | 2330 | 2860 | 3510 | 4230 | 5140 | 5830 | | | | |
| | 50 | 37 | 0 | 0 | 0 | **410** | **640** | 1000 | 1250 | 1540 | 1890 | 2310 | 2840 | 3420 | 4140 | 4700 | 5340 | 5990 | 6530 | 7580 |
| | 60 | 45 | 0 | 0 | 0 | 0 | **540** | 850 | 1060 | 1300 | 1600 | 1960 | 2400 | 2890 | 3500 | 3970 | 4520 | 5070 | 5530 | 6410 |
| | 75 | 55 | 0 | 0 | 0 | 0 | 0 | **690** | 860 | 1060 | 1310 | 1600 | 1970 | 2380 | 2890 | 3290 | 3750 | 5220 | 4610 | 5370 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | **640** | **790** | 970 | 1190 | 1460 | 1770 | 2150 | 2440 | 2790 | 3140 | 3430 | 3990 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **630** | **770** | **950** | 1160 | 1400 | 1690 | 1920 | 2180 | 2440 | 2650 | 3070 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **660** | **800** | **990** | 1190 | 1440 | 1630 | 1860 | 2080 | 2270 | 2640 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **700** | **870** | **1050** | 1270 | 1450 | 1650 | 1860 | 2030 | 2360 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **760** | **920** | **1110** | 1260 | 1440 | 1620 | 1760 | 2050 |

See Footnotes on Page 11 for information on bold figures.

## Table 20 Three Phase 75°C Cable (Continued)

| Motor Rating | | | 75°C Insulation - AWG Copper Wire Size | | | | | | | | | | | | | MCM Copper Wire Size | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | HP | KW | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 | 1 | 0 | 00 | 000 | 0000 | 250 | 300 | 350 | 400 | 500 |
| 200V | 5 | 3.7 | 160 | 250 | 420 | 660 | 1030 | 1620 | 2020 | 2490 | 3060 | 3730 | 4570 | 5500 | 6660 | 7540 | | | | |
| 60Hz | 7 1/2 | 5.5 | 110 | 180 | 300 | 460 | 730 | 1150 | 1440 | 1770 | 2170 | 2650 | 3250 | 3900 | 4720 | 5340 | | | | |
| Three | 10 | 7.5 | **80** | 130 | 210 | 340 | 550 | 850 | 1080 | 1320 | 1630 | 1990 | 2460 | 2950 | 3580 | 4080 | 4650 | 5220 | 5700 | 6630 |
| Phase | 15 | 11 | 0 | 0 | 140 | 240 | 370 | 580 | 730 | 900 | 1110 | 1360 | 1660 | 2010 | 2440 | 2770 | 3150 | 3520 | 3850 | 4470 |
| 6 - Lead | 20 | 15 | 0 | 0 | **120** | 170 | 280 | 450 | 570 | 690 | 850 | 1050 | 1290 | 1570 | 1900 | 2160 | 2470 | 2770 | 3030 | 3540 |
| Y-D | 25 | 18.5 | 0 | 0 | 0 | **140** | 220 | 360 | 450 | 550 | 690 | 850 | 1050 | 1260 | 1540 | 1750 | 1990 | 2250 | 2460 | 2850 |
| | 30 | 22 | 0 | 0 | 0 | **120** | **180** | 294 | 370 | 460 | 570 | 700 | 870 | 1050 | 1270 | 1450 | 1660 | 1870 | 2040 | 2380 |
| 230V | 5 | 3.7 | 210 | 340 | 550 | 880 | 1380 | 2140 | 2680 | 3280 | 4030 | 4930 | 6040 | 7270 | 8800 | 9970 | | | | |
| 60Hz | 7 1/2 | 5.5 | 150 | 240 | 390 | 630 | 970 | 1530 | 1900 | 2340 | 2880 | 3510 | 4300 | 5160 | 6240 | 7060 | 8010 | 8950 | 9750 | |
| Three | 10 | 7.5 | **110** | 180 | 280 | 460 | 730 | 1140 | 1420 | 1750 | 2160 | 2640 | 3240 | 3910 | 4740 | 5380 | 6150 | 6900 | 7530 | 8760 |
| Phase | 15 | 11 | 0 | **130** | 190 | 310 | 490 | 780 | 970 | 1200 | 1470 | 1800 | 2200 | 2670 | 3220 | 3660 | 4170 | 4660 | 5100 | 5910 |
| 6 - Lead | 20 | 15 | 0 | 0 | **140** | 230 | 370 | 600 | 750 | 910 | 1140 | 1390 | 1710 | 2070 | 2520 | 2860 | 3270 | 3670 | 4020 | 4680 |
| Y-D | 25 | 18.5 | 0 | 0 | **120** | 190 | 300 | 480 | 600 | 750 | 910 | 1120 | 1380 | 1680 | 2040 | 2310 | 2640 | 2970 | 3240 | 3780 |
| | 30 | 22 | 0 | 0 | 0 | **150** | 240 | 390 | 490 | 610 | 760 | 930 | 1140 | 1390 | 1690 | 1920 | 2200 | 2470 | 2700 | 3160 |
| 380V | 5 | 3.7 | 600 | 960 | 1510 | 2380 | 3730 | 5800 | 7170 | 8800 | | | | | | | | | | |
| 60Hz | 7 1/2 | 5.5 | 400 | 660 | 1030 | 1630 | 2560 | 3960 | 4890 | 6000 | 7390 | 9010 | | | | | | | | |
| Three | 10 | 7.5 | 300 | 480 | 760 | 1200 | 1870 | 2890 | 3570 | 4360 | 5350 | 6490 | 7840 | 9390 | | | | | | |
| Phase | 15 | 11 | 210 | 340 | 550 | 880 | 1380 | 2140 | 2650 | 3250 | 4030 | 4930 | 6000 | 7260 | 8650 | 9780 | | | | |
| 6 - Lead | 20 | 15 | **160** | 260 | 410 | 660 | 1050 | 1630 | 2020 | 2500 | 3090 | 3790 | 4630 | 5640 | 6750 | 7660 | 4260 | 9760 | | |
| Y-D | 25 | 18.5 | 0 | **210** | 330 | 540 | 850 | 1320 | 1650 | 2020 | 2500 | 3070 | 3760 | 4560 | 5460 | 6190 | 7080 | 7870 | 8610 | 9880 |
| | 30 | 22 | 0 | 0 | **270** | 430 | 700 | 1090 | 1360 | 1680 | 2070 | 2550 | 3120 | 3780 | 4530 | 5140 | 5880 | 6540 | 7150 | 8230 |
| | 40 | 30 | 0 | 0 | **210** | 320 | 510 | 790 | 990 | 1230 | 1510 | 1860 | 2280 | 2760 | 3300 | 3750 | 4270 | 4750 | 5200 | 5980 |
| | 50 | 37 | 0 | 0 | 0 | **250** | 400 | 630 | 810 | 990 | 1230 | 1500 | 1830 | 2220 | 2650 | 3010 | 3430 | 3820 | 4170 | 4780 |
| | 60 | 45 | 0 | 0 | 0 | 0 | **340** | 540 | 660 | 840 | 1030 | 1270 | 1540 | 1870 | 2250 | 2550 | 2910 | 3220 | 3520 | 4050 |
| | 75 | 55 | 0 | 0 | 0 | 0 | **290** | 450 | 550 | 690 | 855 | 1050 | 1290 | 1570 | 1900 | 2160 | 2490 | 2770 | 3040 | 3520 |
| | 100 | 75 | 0 | 0 | 0 | 0 | 0 | **340** | **420** | 520 | 640 | 760 | 940 | 1140 | 1360 | 1540 | 1770 | 1960 | 2140 | 2470 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | 0 | **340** | **400** | **490** | 600 | 730 | 930 | 1110 | 1260 | 1420 | 1590 | 1740 | 1990 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **350** | **420** | **510** | 620 | 750 | 930 | 1050 | 1180 | 1320 | 1440 | 1630 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **360** | **440** | **540** | 660 | 780 | 970 | 1120 | 1260 | 1380 | 1600 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **410** | **480** | **580** | 690 | 790 | 940 | 1050 | 1140 | 1320 |
| 460V | 5 | 3.7 | 880 | 1420 | 2250 | 3540 | 5550 | 8620 | | | | | | | | | | | | |
| 60Hz | 7 1/2 | 5.5 | 630 | 1020 | 1600 | 2530 | 3960 | 6150 | 7650 | 9390 | | | | | | | | | | |
| Three | 10 | 7.5 | 460 | 750 | 1180 | 1870 | 2940 | 4570 | 5700 | 7020 | 8620 | | | | | | | | | |
| Phase | 15 | 11 | 310 | 510 | 810 | 1270 | 2010 | 3130 | 3900 | 4800 | 5890 | 7210 | 8850 | | | | | | | |
| 6 - Lead | 20 | 15 | **230** | 380 | 610 | 970 | 1540 | 2410 | 3000 | 3700 | 4560 | 5590 | 6870 | 8290 | | | | | | |
| Y-D | 25 | 18.5 | **190** | 310 | 490 | 790 | 1240 | 1950 | 2430 | 2980 | 3670 | 4510 | 5550 | 6700 | 8140 | | | | | |
| | 30 | 22 | 0 | **250** | 410 | 640 | 1020 | 1600 | 1990 | 2460 | 3040 | 3730 | 4590 | 5550 | 6750 | 7690 | 8790 | | | |
| | 40 | 30 | 0 | 0 | **300** | 480 | 750 | 1180 | 1470 | 1810 | 2230 | 2740 | 3370 | 4060 | 4930 | 5590 | 6370 | | | |
| | 50 | 37 | 0 | 0 | **250** | 370 | 590 | 960 | 1200 | 1470 | 1810 | 2220 | 2710 | 3280 | 3970 | 4510 | 5130 | 5740 | 6270 | 7270 |
| | 60 | 45 | 0 | 0 | 0 | **320** | 500 | 810 | 1000 | 1240 | 1530 | 1870 | 2310 | 2770 | 3360 | 3810 | 4330 | 4860 | 5310 | 6150 |
| | 75 | 55 | 0 | 0 | 0 | 0 | **420** | 660 | 810 | 1020 | 1260 | 1540 | 1890 | 2280 | 2770 | 3150 | 3600 | 4050 | 4420 | 5160 |
| | 100 | 75 | 0 | 0 | 0 | 0 | **310** | **500** | 610 | 760 | 930 | 1140 | 1410 | 1690 | 2070 | 2340 | 2680 | 3010 | 3280 | 3820 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | **390** | **470** | **590** | 730 | 880 | 1110 | 1330 | 1500 | 1830 | 2080 | 2340 | 2550 | 2940 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | 0 | **420** | **510** | **630** | 770 | 950 | 1140 | 1380 | 1570 | 1790 | 2000 | 2180 | 2530 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **450** | **550** | **680** | 830 | 1000 | 1220 | 1390 | 1580 | 1780 | 1950 | 2270 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **480** | **590** | **730** | 880 | 1070 | 1210 | 1380 | 1550 | 1690 | 1970 |
| 575V | 5 | 3.7 | 1380 | 2220 | 3490 | 5520 | 8620 | | | | | | | | | | | | | |
| 60Hz | 7 1/2 | 5.5 | 990 | 1590 | 2520 | 3970 | 6220 | | | | | | | | | | | | | |
| Three | 10 | 7.5 | 730 | 1170 | 1860 | 2920 | 4590 | 7150 | 8910 | | | | | | | | | | | |
| Phase | 15 | 11 | 490 | 790 | 1270 | 2010 | 3130 | 4890 | 6090 | | | | | | | | | | | |
| 6 - Lead | 20 | 15 | 370 | 610 | 970 | 1540 | 2410 | 3780 | 4710 | 5790 | 7140 | 8740 | | | | | | | | |
| Y-D | 25 | 18.5 | **300** | 490 | 780 | 1240 | 1950 | 3040 | 3790 | 4660 | 5760 | 7060 | | | | | | | | |
| | 30 | 22 | **240** | 400 | 645 | 1020 | 1600 | 2500 | 3120 | 3840 | 4740 | 5820 | 7150 | 8670 | | | | | | |
| | 40 | 30 | 0 | **300** | 480 | 750 | 1180 | 1860 | 2310 | 2850 | 3490 | 4290 | 5260 | 6340 | 7710 | 8740 | | | | |
| | 50 | 37 | 0 | 0 | **380** | 590 | 960 | 1500 | 1870 | 2310 | 2830 | 3460 | 4260 | 5130 | 6210 | 7050 | 8010 | 8980 | 9790 | |
| | 60 | 45 | 0 | 0 | **330** | 500 | 790 | 1270 | 1590 | 1950 | 2400 | 2940 | 3600 | 4330 | 5250 | 5950 | 6780 | 7600 | 8290 | 9610 |
| | 75 | 55 | 0 | 0 | 0 | **420** | 660 | 1030 | 1290 | 1590 | 1960 | 2400 | 2950 | 3570 | 4330 | 4930 | 5620 | 6330 | 6910 | 8050 |
| | 100 | 75 | 0 | 0 | 0 | 0 | **400** | 780 | 960 | 1180 | 1450 | 1780 | 2190 | 2650 | 3220 | 3660 | 4180 | 4710 | 5140 | 5980 |
| | 125 | 90 | 0 | 0 | 0 | 0 | 0 | **600** | 740 | 920 | 1150 | 1420 | 1740 | 2100 | 2530 | 2880 | 3270 | 3660 | 3970 | 4600 |
| | 150 | 110 | 0 | 0 | 0 | 0 | 0 | **520** | **650** | 800 | 990 | 1210 | 1480 | 1780 | 2160 | 2450 | 2790 | 3120 | 3410 | 3950 |
| | 175 | 130 | 0 | 0 | 0 | 0 | 0 | 0 | **570** | **700** | 860 | 1060 | 1300 | 1570 | 1910 | 2170 | 2480 | 2780 | 3040 | 3540 |
| | 200 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | **500** | **610** | **760** | 930 | 1140 | 1370 | 1670 | 1890 | 2160 | 2420 | 2640 | 3070 |

See Footnotes on Page 11 for information on bold figures.

## Table 21 Three Phase Motor Specifications (60 Hz)

| Type | Motor Model Prefix | Rating | | | | | Full Load Amps | Maximum (S.F. Load) Amps | Line to Line Resistance Ohms | Efficiency % | | | Locked Rotor Amps | KVA Code | Circuit Breakers or Fuse Amps | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HP | KW | Volts | Hz | S.F. | | | | S.F. | F.L. | 3/4 | | | Nontime Delay (Std.) Fuse | Dual Element Time Delay Fuse | Inverse Time Breaker |
| 4 Inch | 234501 | 1/2 | 0.37 | 200 | 60 | 1.60 | 2.8 | 3.4 | 6.6-7.3 | 70 | 64 | 58 | 17.5 | N | 10 | 5 | 8 |
| | 234511 | 1/2 | 0.37 | 230 | 60 | 1.60 | 2.4 | 2.9 | 9.5-10.4 | 70 | 64 | 58 | 15.2 | N | 8 | 5 | 6 |
| | 234541 | 1/2 | 0.37 | 380 | 60 | 1.60 | 1.5 | 1.8 | 23.2-23.4 | 70 | 64 | 58 | 9.2 | N | 5 | 3 | 4 |
| | 234521 | 1/2 | 0.37 | 460 | 60 | 1.60 | 1.2 | 1.5 | 38.4-41.6 | 70 | 64 | 58 | 7.6 | N | 4 | 3 | 3 |
| | 234502 | 3/4 | 0.55 | 200 | 60 | 1.50 | 3.7 | 4.4 | 4.6-5.1 | 73 | 69 | 65 | 23.1 | M | 15 | 8 | 10 |
| | 234512 | 3/4 | 0.55 | 230 | 60 | 1.50 | 3.2 | 3.8 | 7.2-7.8 | 73 | 69 | 65 | 20.1 | M | 10 | 6 | 8 |
| | 234542 | 3/4 | 0.55 | 380 | 60 | 1.50 | 1.9 | 2.3 | 16.6-20.3 | 73 | 69 | 65 | 12.2 | M | 6 | 4 | 5 |
| | 234522 | 3/4 | 0.55 | 460 | 60 | 1.50 | 1.6 | 1.9 | 27.8-30.2 | 73 | 69 | 65 | 10.7 | M | 5 | 3 | 4 |
| | 234503 | 1 | 0.75 | 200 | 60 | 1.40 | 4.6 | 5.4 | 4.1-4.5 | 72 | 70 | 66 | 30.9 | M | 15 | 10 | 15 |
| | 234513 | 1 | 0.75 | 230 | 60 | 1.40 | 4.0 | 4.7 | 5.2-5.6 | 72 | 70 | 66 | 26.9 | M | 15 | 8 | 10 |
| | 234543 | 1 | 0.75 | 380 | 60 | 1.40 | 2.4 | 2.8 | 12.2-14.9 | 72 | 70 | 66 | 16.3 | M | 8 | 5 | 8 |
| | 234523 | 1 | 0.75 | 460 | 60 | 1.40 | 2.0 | 2.4 | 21.2-23.0 | 72 | 70 | 66 | 13.5 | M | 6 | 4 | 5 |
| | 234504 | 1 1/2 | 1.1 | 200 | 60 | 1.30 | 5.6 | 6.8 | 2.5-3.0 | 76 | 76 | 74 | 38.2 | K | 20 | 10 | 15 |
| | 234514 | 1 1/2 | 1.1 | 230 | 60 | 1.30 | 4.9 | 5.9 | 3.2-4.0 | 76 | 76 | 74 | 33.2 | K | 15 | 10 | 15 |
| | 234544 | 1 1/2 | 1.1 | 380 | 60 | 1.30 | 3.0 | 3.6 | 8.5-10.4 | 76 | 76 | 74 | 20.1 | K | 10 | 6 | 8 |
| | 234524 | 1 1/2 | 1.1 | 460 | 60 | 1.30 | 2.5 | 3.0 | 13.0-16.0 | 76 | 76 | 74 | 16.6 | K | 8 | 5 | 8 |
| | 234534 | 1 1/2 | 1.1 | 575 | 60 | 1.30 | 2.0 | 2.4 | 20.3-25.0 | 76 | 76 | 74 | 13.3 | K | 6 | 4 | 5 |
| | 234305 | 2 | 1.5 | 200 | 60 | 1.25 | 7.9 | 9.3 | 1.9-2.4 | 69 | 69 | 67 | 53.6 | L | 25 | 15 | 20 |
| | 234315 | 2 | 1.5 | 230 | 60 | 1.25 | 6.9 | 8.1 | 2.4-3.0 | 69 | 69 | 67 | 46.6 | L | 25 | 15 | 20 |
| | 234345 | 2 | 1.5 | 380 | 60 | 1.25 | 4.2 | 4.9 | 6.6-8.2 | 69 | 69 | 67 | 28.2 | L | 15 | 8 | 15 |
| | 234325 | 2 | 1.5 | 460 | 60 | 1.25 | 3.5 | 4.1 | 9.7-12.0 | 69 | 69 | 67 | 23.3 | L | 15 | 8 | 10 |
| | 234335 | 2 | 1.5 | 575 | 60 | 1.25 | 2.8 | 3.2 | 15.1-18.7 | 69 | 69 | 67 | 18.6 | L | 10 | 5 | 8 |
| | 234306 | 3 | 2.2 | 200 | 60 | 1.15 | 11.3 | 12.4 | 1.3-1.7 | 75 | 75 | 73 | 71.2 | K | 35 | 20 | 30 |
| | 234316 | 3 | 2.2 | 230 | 60 | 1.15 | 9.8 | 10.8 | 1.8-2.2 | 75 | 75 | 73 | 61.9 | K | 30 | 20 | 25 |
| | 234346 | 3 | 2.2 | 380 | 60 | 1.15 | 5.9 | 6.5 | 4.7-6.0 | 75 | 75 | 73 | 37.5 | K | 20 | 15 | 15 |
| | 234326 | 3 | 2.2 | 460 | 60 | 1.15 | 4.9 | 5.4 | 7.0-8.7 | 75 | 75 | 73 | 31.0 | K | 15 | 10 | 15 |
| | 234336 | 3 | 2.2 | 575 | 60 | 1.15 | 3.9 | 4.3 | 10.9-13.6 | 75 | 75 | 73 | 24.8 | K | 15 | 8 | 10 |
| | 234307 | 5 | 3.7 | 200 | 60 | 1.15 | 18.4 | 20.4 | .70-.94 | 74 | 74 | 72 | 122.0 | K | 60 | 35 | 50 |
| | 234317 | 5 | 3.7 | 230 | 60 | 1.15 | 16.0 | 17.7 | .93-1.2 | 74 | 74 | 72 | 106.0 | K | 50 | 30 | 40 |
| | 234347 | 5 | 3.7 | 380 | 60 | 1.15 | 9.7 | 10.7 | 2.4-3.0 | 74 | 74 | 72 | 64.4 | K | 30 | 20 | 25 |
| | 234327 | 5 | 3.7 | 460 | 60 | 1.15 | 8.0 | 8.9 | 3.6-4.4 | 74 | 74 | 72 | 53.2 | K | 25 | 15 | 20 |
| | 234337 | 5 | 3.7 | 575 | 60 | 1.15 | 6.4 | 7.1 | 5.6-6.9 | 74 | 74 | 72 | 42.6 | K | 20 | 15 | 20 |
| | 234308 | 7 1/2 | 5.5 | 200 | 60 | 1.15 | 27.1 | 29.9 | .46-.57 | 76 | 76 | 74 | 188.0 | K | 90 | 50 | 70 |
| | 234318 | 7 1/2 | 5.5 | 230 | 60 | 1.15 | 23.6 | 26.0 | .61-.75 | 76 | 76 | 74 | 164.0 | K | 80 | 45 | 60 |
| | 234348 | 7 1/2 | 5.5 | 380 | 60 | 1.15 | 14.3 | 15.7 | 1.6-2.3 | 76 | 76 | 74 | 99.1 | K | 45 | 25 | 40 |
| | 234328 | 7 1/2 | 5.5 | 460 | 60 | 1.15 | 11.8 | 13.0 | 2.4-3.4 | 76 | 76 | 74 | 81.9 | K | 40 | 25 | 30 |
| | 234338 | 7 1/2 | 5.5 | 575 | 60 | 1.15 | 9.4 | 10.4 | 3.5-5.1 | 76 | 76 | 74 | 65.5 | K | 30 | 20 | 25 |
| | 234349 | 10 | 7.5 | 380 | 60 | 1.15 | 20.6 | 22.4 | 1.2-1.6 | 75 | 75 | 72 | 140.0 | L | 70 | 40 | 60 |
| | 234329 | 10 | 7.5 | 460 | 60 | 1.15 | 17.0 | 18.5 | 1.8-2.3 | 75 | 75 | 72 | 116.0 | L | 60 | 30 | 45 |
| | 234339 | 10 | 7.5 | 575 | 60 | 1.15 | 13.6 | 14.8 | 2.8-3.5 | 75 | 75 | 72 | 92.8 | L | 45 | 25 | 35 |

**Table 22 Three Phase Motor Specifications (60 Hz)**

| Type | Motor Model Prefix | Rating | | | | | Full Load Amps | Maximum (S.F. Load) Amps | Line to Line Resistance Ohms | Efficiency % | | | Locked Rotor Amps | KVA Code | Circuit Breakers or Fuse Amps | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HP | KW | Volts | Hz | S.F. | | | | S.F. | F.L. | 3/4 | | | Nontime Delay (Std.) Fuse | Dual Element Time Delay Fuse | Inverse Time Breaker |
| 6 Inch | 236650 | 5 | 3.7 | 200 | 60 | 1.15 | 17.5 | 19.1 | .68-.84 | 79 | 79 | 77 | 99 | H | 60 | 35 | 45 |
| | 236600 | 5 | 3.7 | 230 | 60 | 1.15 | 15 | 16.6 | .88-1.09 | 79 | 79 | 77 | 86 | H | 45 | 30 | 40 |
| | 236660 | 5 | 3.7 | 380 | 60 | 1.15 | 9.1 | 10 | 2.4-3.0 | 79 | 79 | 77 | 52 | H | 30 | 20 | 25 |
| | 236610 | 5 | 3.7 | 460 | 60 | 1.15 | 7.5 | 8.8 | 3.5-4.0 | 79 | 79 | 77 | 43 | H | 25 | 15 | 20 |
| | 236620 | 5 | 3.7 | 575 | 60 | 1.15 | 6 | 6.6 | 5.9-7.2 | 79 | 79 | 77 | 34 | H | 20 | 15 | 15 |
| | 236651 | 7 1/2 | 5.5 | 200 | 60 | 1.15 | 25.1 | 28.3 | .39-.48 | 80 | 80 | 78 | 150 | H | 80 | 45 | 70 |
| | 236601 | 7 1/2 | 5.5 | 230 | 60 | 1.15 | 21.8 | 24.6 | .57-.71 | 80 | 80 | 78 | 130 | H | 70 | 40 | 60 |
| | 236661 | 7 1/2 | 5.5 | 380 | 60 | 1.15 | 13.2 | 14.9 | 1.5-1.8 | 80 | 80 | 78 | 79 | H | 45 | 25 | 35 |
| | 236611 | 7 1/2 | 5.5 | 460 | 60 | 1.15 | 10.9 | 12.3 | 2.2-2.7 | 80 | 80 | 78 | 65 | H | 35 | 20 | 30 |
| | 236621 | 7 1/2 | 5.5 | 575 | 60 | 1.15 | 8.7 | 9.8 | 3.6-4.4 | 80 | 80 | 78 | 52 | H | 30 | 20 | 25 |
| | 236652 | 10 | 7.5 | 200 | 60 | 1.15 | 32.7 | 37 | .33-.42 | 79 | 79 | 78 | 198 | H | 100 | 60 | 90 |
| | 236602 | 10 | 7.5 | 230 | 60 | 1.15 | 28.4 | 32.2 | .44-.55 | 79 | 79 | 78 | 172 | H | 90 | 60 | 80 |
| | 236662 | 10 | 7.5 | 380 | 60 | 1.15 | 17.2 | 19.5 | 1.2-1.5 | 79 | 79 | 78 | 104 | H | 60 | 35 | 45 |
| | 236612 | 10 | 7.5 | 460 | 60 | 1.15 | 14.2 | 16.1 | 1.7-2.2 | 79 | 79 | 78 | 86 | H | 45 | 30 | 40 |
| | 236622 | 10 | 7.5 | 575 | 60 | 1.15 | 11.4 | 12.9 | 2.8-3.5 | 79 | 79 | 78 | 69 | H | 35 | 25 | 30 |
| | 236653 | 15 | 11 | 200 | 60 | 1.15 | 47.8 | 54.5 | .22-.27 | 81 | 81 | 80 | 306 | H | 150 | 90 | 125 |
| | 236603 | 15 | 11 | 230 | 60 | 1.15 | 41.6 | 47.4 | .27-.33 | 81 | 81 | 80 | 266 | H | 150 | 80 | 110 |
| | 236663 | 15 | 11 | 380 | 60 | 1.15 | 25.2 | 28.7 | .73-.90 | 81 | 81 | 80 | 161 | H | 80 | 45 | 70 |
| | 236613 | 15 | 11 | 460 | 60 | 1.15 | 20.8 | 23.7 | 1.1-1.3 | 81 | 81 | 80 | 133 | H | 70 | 40 | 60 |
| | 236623 | 15 | 11 | 575 | 60 | 1.15 | 16.7 | 19 | 1.7-2.1 | 81 | 81 | 80 | 106 | H | 60 | 30 | 45 |
| | 236654 | 20 | 15 | 200 | 60 | 1.15 | 61.9 | 69.7 | .14-.17 | 82 | 82 | 81 | 416 | J | 200 | 110 | 175 |
| | 236604 | 20 | 15 | 230 | 60 | 1.15 | 53.8 | 60.6 | .20-.25 | 82 | 82 | 81 | 362 | J | 175 | 100 | 150 |
| | 236664 | 20 | 15 | 380 | 60 | 1.15 | 32.6 | 36.7 | .52-.64 | 82 | 82 | 81 | 219 | J | 100 | 60 | 90 |
| | 236614 | 20 | 15 | 460 | 60 | 1.15 | 26.9 | 30.3 | .76-.94 | 82 | 82 | 81 | 181 | J | 90 | 50 | 70 |
| | 236624 | 20 | 15 | 575 | 60 | 1.15 | 21.5 | 24.4 | 1.2-1.5 | 82 | 82 | 81 | 145 | J | 70 | 40 | 60 |
| | 236655 | 25 | 18.5 | 200 | 60 | 1.15 | 77.1 | 86.3 | .11-.14 | 83 | 83 | 82 | 552 | J | 250 | 150 | 200 |
| | 236605 | 25 | 18.5 | 230 | 60 | 1.15 | 67 | 75 | .15-.19 | 83 | 83 | 82 | 480 | J | 225 | 125 | 175 |
| | 236665 | 25 | 18.5 | 380 | 60 | 1.15 | 40.6 | 45.4 | .40-.50 | 83 | 83 | 82 | 291 | J | 125 | 80 | 110 |
| | 236615 | 25 | 18.5 | 460 | 60 | 1.15 | 33.5 | 37.5 | .59-.73 | 83 | 83 | 82 | 240 | J | 110 | 60 | 90 |
| | 236625 | 25 | 18.5 | 575 | 60 | 1.15 | 26.8 | 30 | 1.0-1.3 | 83 | 83 | 82 | 192 | J | 90 | 50 | 70 |
| | 236656 | 30 | 22 | 200 | 60 | 1.15 | 90.9 | 104 | .10-.12 | 83 | 83 | 86 | 653 | J | 300 | 175 | 250 |
| | 236606 | 30 | 22 | 230 | 60 | 1.15 | 79 | 90.4 | .12-.15 | 83 | 83 | 86 | 568 | J | 250 | 150 | 225 |
| | 236666 | 30 | 22 | 380 | 60 | 1.15 | 47.8 | 54.7 | .33-.41 | 83 | 83 | 86 | 317 | J | 150 | 90 | 125 |
| | 236616 | 30 | 22 | 460 | 60 | 1.15 | 39.5 | 45.2 | .48-.60 | 83 | 83 | 86 | 284 | J | 125 | 80 | 110 |
| | 236626 | 30 | 22 | 575 | 60 | 1.15 | 31.6 | 36.2 | .78-.95 | 83 | 83 | 86 | 227 | J | 100 | 60 | 90 |
| | 236667 | 40 | 30 | 380 | 60 | 1.15 | 64.8 | 75 | .20-.27 | 83 | 83 | 83 | 481 | J | 200 | 125 | 175 |
| | 236617 | 40 | 30 | 460 | 60 | 1.15 | 53.5 | 62 | .32-.40 | 83 | 83 | 83 | 397 | J | 175 | 100 | 150 |
| | 236627 | 40 | 30 | 575 | 60 | 1.15 | 42.8 | 49.6 | .53-.59 | 83 | 83 | 83 | 318 | H | 150 | 80 | 110 |
| | 236668 | 50 | 37 | 380 | 60 | 1.15 | 82 | 93.2 | .17-.22 | 82 | 83 | 83 | 501 | H | 250 | 150 | 225 |
| | 236618 | 50 | 37 | 460 | 60 | 1.15 | 67.7 | 77 | .25-.32 | 82 | 83 | 83 | 414 | H | 225 | 125 | 175 |
| | 236628 | 50 | 37 | 575 | 60 | 1.15 | 54.2 | 61.6 | .39-.48 | 82 | 83 | 83 | 331 | H | 175 | 100 | 150 |
| | 236669 | 60 | 45 | 380 | 60 | 1.15 | 97.4 | 110.2 | .15-.18 | 84 | 84 | 84 | 627 | H | 300 | 175 | 250 |
| | 236619 | 60 | 45 | 460 | 60 | 1.15 | 80.5 | 91 | .22-.27 | 84 | 84 | 84 | 518 | H | 250 | 150 | 225 |
| | 236629 | 60 | 45 | 575 | 60 | 1.15 | 64.4 | 72.8 | .35-.39 | 84 | 84 | 84 | 414 | H | 200 | 125 | 175 |

Model numbers are three lead motors. Six lead motors with different model numbers have the same running performance, but when wye connected for starting have locked rotor amps 33% of the values shown.

### Table 23 Three Phase Motor Specifications (60 Hz)

| Type | Motor Model Prefix | Rating | | | | | Full Load Amps | Maximum (S.F. Load) Amps | Line to Line Resistance Ohms | Efficiency % | | | Locked Rotor Amps | KVA Code | Circuit Breakers or Fuse Amps | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | HP | KW | Volts | Hz | S.F. | | | | S.F. | F.L. | 3/4 | | | Nontime Delay (Std.) Fuse | Dual Element Time Delay Fuse | Inverse Time Breaker |
| | 239660 | 40 | 30 | 380 | 60 | 1.15 | 64 | 72 | .162-.198 | 86 | 86 | 85 | 479 | J | 200 | 125 | 175 |
| 8 | 239600 | 40 | 30 | 460 | 60 | 1.15 | 53 | 60 | .247-.303 | 86 | 86 | 85 | 396 | J | 175 | 100 | 150 |
| Inch | 239610 | 40 | 30 | 575 | 60 | 1.15 | 42 | 48 | .399-.487 | 86 | 86 | 85 | 317 | J | 150 | 80 | 110 |
| | 239661 | 50 | 37 | 380 | 60 | 1.15 | 77 | 88 | .127-.156 | 87 | 87 | 86 | 656 | K | 250 | 150 | 200 |
| | 239601 | 50 | 37 | 460 | 60 | 1.15 | 64 | 73 | .181-.221 | 87 | 87 | 86 | 542 | K | 200 | 125 | 175 |
| | 239611 | 50 | 37 | 575 | 60 | 1.15 | 51 | 59 | .280-.342 | 87 | 87 | 86 | 434 | K | 175 | 90 | 150 |
| | 239662 | 60 | 45 | 380 | 60 | 1.15 | 92 | 104 | .090-.110 | 88 | 87 | 86 | 797 | K | 300 | 175 | 250 |
| | 239602 | 60 | 45 | 460 | 60 | 1.15 | 76 | 86 | .142-.174 | 88 | 87 | 86 | 658 | K | 250 | 150 | 200 |
| | 239612 | 60 | 45 | 575 | 60 | 1.15 | 61 | 69 | .227-.277 | 88 | 87 | 86 | 526 | K | 200 | 110 | 175 |
| | 239663 | 75 | 55 | 380 | 60 | 1.15 | 114 | 130 | .069-.085 | 88 | 88 | 87 | 1046 | L | 350 | 200 | 300 |
| | 239603 | 75 | 55 | 460 | 60 | 1.15 | 94 | 107 | .106-.130 | 88 | 88 | 87 | 864 | L | 300 | 175 | 250 |
| | 239613 | 75 | 55 | 575 | 60 | 1.15 | 76 | 86 | .169-.207 | 88 | 88 | 87 | 691 | L | 250 | 150 | 200 |
| | 239664 | 100 | 75 | 380 | 60 | 1.15 | 153 | 172 | .051-.062 | 89 | 89 | 88 | 1466 | L | 500 | 300 | 400 |
| | 239604 | 100 | 75 | 460 | 60 | 1.15 | 126 | 142 | .073-.089 | 89 | 89 | 88 | 1211 | L | 400 | 225 | 350 |
| | 239614 | 100 | 75 | 575 | 60 | 1.15 | 101 | 114 | .110-.134 | 89 | 89 | 88 | 969 | L | 350 | 200 | 300 |
| | 239165 | 125 | 90 | 380 | 60 | 1.15 | 202 | 228 | .032-.042 | 87 | 86 | 85 | 1596 | K | 700 | 400 | 600 |
| | 239105 | 125 | 90 | 460 | 60 | 1.15 | 167 | 188 | .055-.067 | 87 | 86 | 85 | 1318 | K | 500 | 300 | 450 |
| | 239115 | 125 | 90 | 575 | 60 | 1.15 | 134 | 151 | .087-.106 | 87 | 86 | 85 | 1054 | K | 450 | 250 | 350 |
| | 239166 | 150 | 110 | 380 | 60 | 1.15 | 235 | 266 | .028-.034 | 88 | 87 | 86 | 1961 | K | 800 | 450 | 600 |
| | 239106 | 150 | 110 | 460 | 60 | 1.15 | 194 | 219 | .042-.051 | 88 | 87 | 86 | 1620 | K | 600 | 350 | 500 |
| | 239116 | 150 | 110 | 575 | 60 | 1.15 | 155 | 176 | .067-.082 | 88 | 87 | 86 | 1296 | K | 500 | 300 | 400 |
| | 239167 | 175 | 130 | 380 | 60 | 1.15 | 265 | 302 | .028-.035 | 88 | 88 | 87 | 1991 | J | 800 | 500 | 700 |
| | 239107 | 175 | 130 | 460 | 60 | 1.15 | 219 | 249 | .042-.052 | 88 | 88 | 87 | 1645 | J | 700 | 400 | 600 |
| | 239117 | 175 | 130 | 575 | 60 | 1.15 | 175 | 200 | .063-.077 | 88 | 88 | 87 | 1316 | J | 600 | 350 | 450 |
| | 239168 | 200 | 150 | 380 | 60 | 1.15 | 298 | 342 | .024-.029 | 88 | 88 | 87 | 2270 | J | 1000 | 600 | 800 |
| | 239108 | 200 | 150 | 460 | 60 | 1.15 | 246 | 282 | .036-.044 | 88 | 88 | 87 | 1875 | J | 800 | 450 | 700 |
| | 239118 | 200 | 150 | 575 | 60 | 1.15 | 197 | 226 | .057-.070 | 88 | 88 | 87 | 1500 | J | 600 | 350 | 500 |

Model numbers are three lead motors. Six lead motors with different model numbers have the same running performance, but when wye connected for starting have locked rotor amps 33% of the values shown.

## Overload Protection Of Three Phase Submersible Motors - Class 10 Protection Required

The characteristics of submersible motors are different from standard motors and special overload protection is required.

If the motor is stalled, the overload protector must trip within 10 seconds to protect the motor windings. The installer must use SUBTROL or the quick-trip protection shown in these tables. All recommended overload selections are of the ambient compensated type to maintain protection at high and low air temperatures.

All heaters and amp settings shown are based on total line amps. When a six-lead motor is used with a Wye-Delta starter, divide motor amps by 1.732 to make your selection or adjustment for heaters carrying phase amps.

Tables 24, 25 and 26 list the correct selection and settings for several manufacturers. Approval of other types may be requested.

Refer to notes on Page 25.

**Table 24 60 Hz 4" Motors**

| HP | KW | Volts | NEMA Starter Size | Heaters For Overload Relays | | | Adjustable Relays (Note 4) | |
|---|---|---|---|---|---|---|---|---|
| | | | | Furnas (Note 1) | Allen Bradley (Note 2) | G.E. (Note 3) | Set | Max. |
| 1/2 | 0.37 | 200 | 00 | K31 | J16 | L380A | 3.2 | 3.4 |
| | | 230 | 00 | K28 | J14 | L343A | 2.7 | 2.9 |
| | | 380 | 00 | K22 | J9 | L211A | 1.7 | 1.8 |
| | | 460 | 00 | - | J8 | L174A | 1.4 | 1.5 |
| | | 575 | 00 | - | J6 | - | 1.2 | 1.3 |
| 3/4 | 0.55 | 200 | 00 | K34 | J19 | L51CA | 4.1 | 4.4 |
| | | 230 | 00 | K32 | J17 | L420A | 3.5 | 3.8 |
| | | 380 | 00 | K27 | J13 | L282A | 2.3 | 2.5 |
| | | 460 | 00 | K23 | J10 | L211A | 1.8 | 1.9 |
| | | 575 | 00 | K21 | J8 | L193A | 1.5 | 1.6 |
| 1 | 0.75 | 200 | 00 | K37 | J21 | L618A | 5.0 | 5.4 |
| | | 230 | 00 | K36 | J19 | L561A | 4.4 | 4.7 |
| | | 380 | 00 | K28 | J14 | L310A | 2.6 | 2.8 |
| | | 460 | 00 | K26 | J12 | L282A | 2.2 | 2.4 |
| | | 575 | 00 | K23 | J10 | L211A | 1.8 | 1.9 |
| 1 1/2 | 1.1 | 200 | 00 | K42 | J23 | L750A | 6.3 | 6.8 |
| | | 230 | 00 | K39 | J21 | L680A | 5.5 | 5.9 |
| | | 380 | 00 | K32 | J17 | L420A | 3.3 | 3.6 |
| | | 460 | 00 | K29 | J15 | L343A | 2.8 | 3.0 |
| | | 575 | 00 | K26 | J12 | L282A | 2.2 | 2.4 |
| 2 | 1.5 | 200 | 0 | K50 | J26 | L111B | 8.6 | 9.3 |
| | | 230 | 0 | K49 | J25 | L910A | 7.5 | 8.1 |
| | | 380 | 0 | K36 | J20 | L561A | 4.6 | 4.9 |
| | | 460 | 00 | K33 | J18 | L463A | 3.8 | 4.1 |
| | | 575 | 00 | K29 | J15 | L380A | 3.0 | 3.2 |
| 3 | 2.2 | 200 | 0 | K55 | J29 | L147B | 11.6 | 12.5 |
| | | 230 | 0 | K52 | J28 | L122B | 10.1 | 10.9 |
| | | 380 | 0 | K41 | J23 | L750A | 6.1 | 6.6 |
| | | 460 | 0 | K37 | J21 | L618A | 5.1 | 5.5 |
| | | 575 | 0 | K34 | J19 | L510A | 4.1 | 4.4 |
| 5 | 3.7 | 200 | 1 | K62 | J34 | L241B | 19.1 | 20.5 |
| | | 230 | 1 | K61 | J33 | L199B | 16.6 | 17.8 |
| | | 380 | 0 | K52 | J28 | L122B | 10.0 | 10.8 |
| | | 460 | 0 | K49 | J26 | L100B | 8.3 | 8.9 |
| | | 575 | 0 | K42 | J23 | L825A | 6.6 | 7.1 |
| 7 1/2 | 5.5 | 200 | 1 | K68 | J38 | L332B | 28.4 | 30.5 |
| | | 230 | 1 | K67 | J37 | L293B | 24.6 | 26.4 |
| | | 380 | 1 | K58 | J32 | L181B | 14.9 | 16.0 |
| | | 460 | 1 | K55 | J30 | L147B | 12.3 | 13.2 |
| | | 575 | 1 | K52 | J28 | L122B | 9.9 | 10.6 |
| 10 | 7.5 | 380 | 1 | K63 | J35 | L265B | 21.2 | 22.8 |
| | | 460 | 1 | K61 | J33 | L220B | 17.5 | 18.8 |
| | | 575 | 1 | K57 | J31 | L181B | 14.0 | 15.0 |

### Table 25 60 Hz 6” Motors

| HP | KW | Volts | NEMA Starter Size | Heaters For Overload Relays | | | Adjustable Relays (Note 4) | |
|---|---|---|---|---|---|---|---|---|
| | | | | Furnas (Note 1) | Allen Bradley (Note 2) | G.E. (Note 3) | Set | Max. |
| 5 | 3.7 | 200 | 1 | K61 | J33 | L220B | 17.6 | 19.1 |
| | | 230 | 1 | K60 | J32 | L199B | 15.4 | 16.6 |
| | | 380 | 0 | K52 | J27 | L111B | 9.4 | 10.1 |
| | | 460 | 0 | K49 | J25 | L910A | 7.7 | 8.3 |
| | | 575 | 0 | K41 | J23 | L750A | 6.1 | 6.6 |
| 7 1/2 | 5.5 | 200 | 1 | K67 | J38 | L322B | 26.3 | 28.3 |
| | | 230 | 1 | K64 | J36 | L293B | 22.9 | 24.6 |
| | | 380 | 1 | K57 | J31 | L165B | 13.9 | 14.9 |
| | | 460 | 1 | K54 | J29 | L147B | 11.4 | 12.3 |
| | | 575 | 1 | K52 | J27 | L111B | 9.1 | 9.8 |
| 10 | 7.5 | 200 | 2(1) | K72 | J40 | L426B | 34.4 | 37.0 |
| | | 230 | 2(1) | K70 | J38 | L390B | 29.9 | 32.2 |
| | | 380 | 1 | K61 | J34 | L220B | 18.1 | 19.5 |
| | | 460 | 1 | K58 | J32 | L181B | 15.0 | 16.1 |
| | | 575 | 1 | K55 | J30 | L147B | 12.0 | 12.9 |
| 15 | 11 | 200 | 3(1) | K76 | J43 | L650B | 50.7 | 54.5 |
| | | 230 | 2 | K75 | J42 | L520B | 44.1 | 47.4 |
| | | 380 | 2(1) | K68 | J37 | L322B | 26.7 | 28.7 |
| | | 460 | 2(1) | K64 | J35 | L265B | 22.0 | 23.7 |
| | | 575 | 2(1) | K61 | J33 | L220B | 17.7 | 19.0 |
| 20 | 15 | 200 | 3 | K78 | J45 | L787B | 64.8 | 69.7 |
| | | 230 | 3(1) | K78 | J44 | L710B | 56.4 | 60.6 |
| | | 380 | 2 | K72 | J40 | L426B | 34.1 | 36.7 |
| | | 460 | 2 | K69 | J38 | L352B | 28.2 | 30.3 |
| | | 575 | 2 | K64 | J35 | L393B | 22.7 | 24.4 |
| 25 | 18.5 | 200 | 3 | K86 | J71 | L107C | 80.3 | 86.3 |
| | | 230 | 3 | K83 | J46 | L866B | 69.8 | 75.0 |
| | | 380 | 2 | K74 | J42 | L520B | 42.2 | 45.4 |
| | | 460 | 2 | K72 | J40 | L426B | 34.9 | 37.5 |
| | | 575 | 2 | K69 | J37 | L352B | 27.9 | 30.0 |
| 30 | 22 | 200 | 4(1) | K88 | J72 | L126C | 96.7 | 104.0 |
| | | 230 | 3 | K87 | J71 | L107C | 84.1 | 90.4 |
| | | 380 | 3(1) | K76 | J43 | L650B | 50.9 | 54.7 |
| | | 460 | 3(1) | K74 | J41 | L520B | 42.0 | 45.2 |
| | | 575 | 3(1) | K72 | J39 | L390B | 33.7 | 36.2 |
| 40 | 30 | 380 | 3 | K83 | J46 | L866B | 69.8 | 75.0 |
| | | 460 | 3 | K77 | J44 | L710B | 57.7 | 62.0 |
| | | 575 | 3 | K74 | J42 | L593B | 46.1 | 49.6 |
| 50 | 37 | 380 | 3 | K87 | J72 | L107C | 86.7 | 93.2 |
| | | 460 | 3 | K83 | J46 | L950C | 71.6 | 77.0 |
| | | 575 | 3 | K77 | J44 | L710B | 57.3 | 61.6 |
| 60 | 45 | 380 | 4(1) | K89 | J73 | L126C | 102.5 | 110.2 |
| | | 460 | 4(1) | K87 | J71 | L107C | 84.6 | 91.0 |
| | | 575 | 4(1) | K78 | J45 | L866B | 67.7 | 72.8 |

### Footnotes for Tables 24, 25, and 26

**NOTE 1:** Furnas intermediate sizes between NEMA starter sizes apply where (1) is shown in tables, size 1-3/4 replacing 2, 2-1/2 replacing 3, 3-1/2 replacing 4, and 4-1/2 replacing 5. Heaters were selected from Catalog 294, Table 332 and Table 632 (starter size 00, size B). Size 4 starters are heater type 4 (JG). Starters using these heater tables include classes 14, 17 and 18 (INNOVA), classes 36 and 37 (reduced voltage), and classes 87, 88 and 89 (pump and motor control centers). Overload relay adjustments should be set no higher than 100% unless necessary to stop nuisance tripping with measured amps in all lines below nameplate maximum. Heater selections for class 16 starters (Magnetic Definite Purpose) will be furnished upon request.

**NOTE 2:** Allen-Bradley heaters were selected from Catalog IC-110, Table 162 (through starter size 4), Table 547 (starter size 5), and Table 196 (starter size 6). Bulletin 505, 509, 520, 540 and 570 use these heater tables. Heater selections for bulletin 1232X and 1233X starters will be furnished upon request.

**NOTE 3:** General Electric heaters are type CR123 usable only on type CR124 overload relays and were selected from Catalog GEP-126OJ, page 184. Adjustment should be set no higher than 100%, unless necessary to stop nuisance tripping with measured amps in all lines below nameplate maximum.

**NOTE 4:** Adjustable overload relay amp settings apply to approved types listed. Relay adjustment should be set at the specified SET amps. Only if tripping occurs with amps in all lines measured to be within nameplate maximum amps should the setting be increased, not to exceed the MAX value shown.

**NOTE 5:** Heaters shown for ratings requiring NEMA size 5 or 6 starters are all used with current transformers per manufacturer standards. Adjustable relays may or may not use current transformers depending on design.

# Application - Three Phase Motors

### Recommended Adjustable Overload Relays

**Advance Controls:** MDR3 Overload

**AEG Series:** B17S, B27S, B27-2

**ABB Type:** RVH 40, RVH65, RVP160, T25DU, T25CT, TA25DU

**AGUT:** MT03, R1K1, R1L0, R1L3, TE set Class 5

**Allen Bradley:** Bulletin 193, SMP-Class 10 only

**Automatic Switch Types:** DQ, LR1-D, LR1-F, LR2-D13, -D23, -D33 only

**Bharita C-H:** MC 305 ANA 3

**Clipsal:** 6CTR, 6MTR

**Cutler-Hammer:** C316F, C316P, C316S, C310-set at 6 sec max

**Fanal Types:** K7 or K7D through K400

**Franklin Electric:** Subtrol-Plus

**Fuji Types:** TR-OQ, TR-OQH, TR-2NQ, TR-3NQ, TR-4NQ, TR-6NQ, RCa 3737-ICQ & ICQH

**Furnas Types:** US15 48AG & 48BG, ESP100-Class 10 only, 958L

**General Electric:** CR4G, CR7G, RT*1, RT*2, RTF3, RT*4, CR324X-Class 10 only

**Kasuga:** RU Set Operating Time Code = 10 & time setting 6 sec max

**Klockner-Moeller Types:** ZOO, Z1, Z4, PKZM1, PKZM3 & PKZ2

**Lovato:** RC9, RC22, RC80, RF9, RF25 & RF95

**Matsushita:** FKT-15N, 15GN, 15E, 15GE, FT-15N, FHT-15N

**Mitsubishi:** ET, TH-K12ABKP, TH-K20KF, TH-K20KP, TH-K20TAKF, TH-K60KF, TH-K60TAKF

**Omron:** K2CM Set Operating Timing Code = 10 & time setting 6 sec max, SE-KP24E time setting 6 sec max

**Riken:** PM1, PM3

**Samwha:** EOCRS Set for Class 5, EOCR-ST, EOCR-SE, EOCR-AT time setting 6 sec max

**Siemens Types:** 3UA50, -52, -54, -55, -58, -59, -60, -61, -62, -66, -68, -70, 3VUI3, 3VE, 3UB (Class 5)

**Sprecher and Schuh Types:** CT, CT1, CTA 1, CT3K, CT3-12 thru CT3-42, KTA3, CEF1 & CET3 set at 6 sec max, CEP 7 Class 10, CT4, 6, & 7, CT3

**Square D/Telemecanique:** Class 9065 Types: TD, TE, TF, TG, TJ, TK, TR, TJE & TJF (Class 10) OR LR1-D, LR1-F, LR2-Class 10, Types 18A, 32A, SS- Class 10, SR-Class 10 and 63-A-LB Series. Integral 18,32,63, GV2-L, GV2-M, GV2-P, GV3-M (1.6-10 amp only)

### Table 26 60 Hz 8" Motors

| HP | KW | Volts | NEMA Starter Size | Heaters For Overload Relays: Furnas (Note 1) | Allen Bradley (Note 2) | G.E. (Note 3) | Adjustable Relays (Note 4): Set | Max. |
|---|---|---|---|---|---|---|---|---|
| 40 | 30 | 380 | 3 | K78 | J46 | L866B | 68 | 73 |
| | | 460 | 3 | K77 | J43 | L710B | 56 | 60 |
| | | 575 | 3 | K73 | J41 | L520B | 45 | 48 |
| 50 | 37 | 380 | 3 | K86 | J81 | L107C | 81 | 87 |
| | | 460 | 3 | K78 | J46 | L866B | 68 | 73 |
| | | 575 | 3 | K77 | J43 | L710B | 56 | 60 |
| 60 | 45 | 380 | 4(1) | K89 | J72 | L126C | 101 | 108 |
| | | 460 | 4(1) | K86 | J70 | L107C | 83 | 89 |
| | | 575 | 4(1) | K78 | J44 | L787B | 64 | 69 |
| 75 | 55 | 380 | 4 | K92 | J75 | L142C | 121 | 130 |
| | | 460 | 4(1) | K89 | J72 | L126C | 100 | 107 |
| | | 575 | 4(1) | K85 | J70 | L950C | 79 | 85 |
| 100 | 75 | 380 | 5(1) | K28 | J15 | L100B | 168 | 181 |
| | | 460 | 4 | K92 | J76 | L155C | 134 | 144 |
| | | 575 | 4 | K90 | J73 | L142C | 108 | 116 |
| 125 | 90 | 380 | 5 | K32 | J17 | L135B | 207 | 223 |
| | | 460 | 5(1) | K29 | J15 | L111B | 176 | 189 |
| | | 575 | 5(1) | K26 | J13 | L825A | 140 | 150 |
| 150 | 110 | 380 | 5 | - | J19 | L147B | 248 | 267 |
| | | 460 | 5(1) | K32 | J17 | L122B | 206 | 221 |
| | | 575 | 5(1) | K28 | J14 | L100B | 165 | 177 |
| 175 | 130 | 380 | 6 | K26 | J11 | - | 270 | 290 |
| | | 460 | 5 | K33 | J18 | L147B | 233 | 250 |
| | | 575 | 5 | K31 | J16 | L111B | 186 | 200 |
| 200 | 150 | 380 | 6 | K27 | J12 | - | 316 | 340 |
| | | 460 | 5 | K33 | J20 | L165B | 266 | 286 |
| | | 575 | 5 | K32 | J17 | L135B | 213 | 229 |

**Toshiba Type:** 2E RC820, set at 8 seconds max.

**WEG:** RW2

**Westinghouse Types:** FT13, FT23, FT33, FT43, K7D, K27D, K67D, Advantage (Class 10), MOR, IQ500 (Class 5)

**Westmaster:** OLWROO and OLWTOO suffix D thru P

Other relay types from these and other manufacturers may or may not provide acceptable protection, and they should not be used without approval of Franklin Electric.

Some approved types may only be available for part of the listed motor ratings. When relays are used with current transformers, relay setting is the specified amps divided by the transformer ratio.

## Subtrol-Plus

Subtrol-Plus is a Franklin Electric protection device for 6"and 8" motors that uses microprocessor technology to detect overload, underload, overheat, and rapid cycling. When one of these faults occurs, Subtrol-Plus shuts down the motor and visually displays the fault condition. Some additional features are automatic restart, field adjustable trip settings, and external alarm/back-up system connection.

Subtrol-Plus is supplied as an easy-to-install kit, which fits virtually any three-phase pump panel. Subtrol-Plus calibrates to a particular motor through the use of a rating insert.


Subtrol-Plus easy-to-install kit

## Power Factor Correction

In some installations, power supply limitations make it necessary or desirable to increase the power factor of a submersible motor. The table lists the capacitive KVAR required to increase the power factor of large Franklin three phase submersible motors to the approximate values shown at maximum input loading.

Capacitors must be connected on the line side of the overload relay, or overload protection will be lost.

**Table 27 KVAR Required 60 Hz**

| Motor | | KVAR Required for P.F. of: | | |
|---|---|---|---|---|
| HP | KW | 0.90 | 0.95 | 1.00 |
| 5 | 3.7 | 1.2 | 2.1 | 4 |
| 7 1/2 | 5.5 | 1.7 | 3.1 | 6 |
| 10 | 7.5 | 1.5 | 3.3 | 7 |
| 15 | 11 | 2.2 | 4.7 | 10 |
| 20 | 15 | 1.7 | 5 | 12 |
| 25 | 18.5 | 2.1 | 6.2 | 15 |
| 30 | 22 | 2.5 | 7.4 | 18 |
| 40 | 30 | 4.5 | 11 | 24 |
| 50 | 37 | 7.1 | 15 | 32 |
| 60 | 45 | 8.4 | 18 | 38 |
| 75 | 55 | 6.3 | 18 | 43 |
| 100 | 75 | 11 | 27 | 60 |
| 125 | 90 | 17 | 36 | 77 |
| 150 | 110 | 20 | 42 | 90 |
| 175 | 130 | 9.6 | 36 | 93 |
| 200 | 150 | 16 | 46 | 110 |

# Submersible Pump Installation Check List

**1. Motor Inspection**

❑ A. Verify that the model, HP or KW, voltage, phase and hertz on the motor nameplate match the installation requirements.
❑ B. Check that the motor lead assembly is not damaged.
❑ C. Measure insulation resistance using a 500 or 1000 volt DC megohmmeter from each lead wire to the motor frame. Resistance should be at least 20 megohms with out drop cable.
❑ D. Keep a record of motor model number, HP or KW, voltage, and serial number (S/N). (S/N is stamped in shell above the nameplate. A typical example, S/N 98A18 01-0123)

**2. Pump Inspection**

❑ A. Check that the pump rating matches the motor.
❑ B. Check for pump damage and verify that the pump shaft turns freely.

**3. Pump/Motor Assembly**

❑ A. If not yet assembled, check that pump and motor mounting faces are free from dirt, debris and uneven paint thickness.
❑ B. Pumps and motors over 5HP should be assembled in the vertical position to prevent stress on pump brackets and shafts. Assemble the pump and motor together so their mounting faces are in contact and then tighten assembly bolts or nuts evenly to manufacturer specifications.
❑ C. If accessible, check that the pump shaft turns freely.
❑ D. Assemble the pump lead guard over the motor leads. Do not cut or pinch lead wires during assembly or installation.

**4. Power Supply and Controls**

❑ A. Verify that the power supply voltage, hertz, and KVA capacity match motor requirements.
❑ B. Verify control box HP and voltage matches motor (3-wire only).
❑ C. Check that the electrical installation and controls meet all safety regulations and match the motor requirements, including fuse or circuit breaker size and motor overload protection. Connect all metal plumbing and electrical enclosures to the power supply ground to prevent shock hazard. Comply with national and local codes.

**5. Lightning and Surge Protection**

❑ A. Use properly rated surge (lightning) arrestors on all submersible pump installations. Motors 5HP and smaller, which are marked “Equipped with Lightning Arrestors”, contain internal arrestors.
❑ B. Ground all above ground arrestors with copper wire directly to the motor frame, or to metal drop pipe or casing which reaches below the well pumping level. Connecting to a ground rod does not provide good surge protection.

**6. Electrical Drop Cable**

❑ A. Use submersible cable sized in accordance with local regulations and the cable charts, see Pages 11 and 15-20. Ground motor per national and local codes.
❑ B. Include a ground wire to the motor and surge protection, connected to the power supply ground if required by codes. Always ground any pump operated outside a drilled well.

**7. Motor Cooling**

❑ A. Ensure at all times the installation provides adequate motor cooling; see Page 6 for details.

**8. Pump/Motor Installation**

❑ A. Splice motor leads to supply cable using electrical grade solder or compression connectors, and carefully insulate each splice with watertight tape or adhesive-lined shrink tubing, as shown in motor or pump installation data.
❑ B. Support the cable to the delivery pipe every 10 feet (3 meters) with straps or tape strong enough to prevent sagging. Use padding between cable and any metal straps.
❑ C. A check valve in the delivery pipe is recommended. More than one check valve may be required, depending on valve rating and pump setting; see Page 5 for details.
❑ D. Assemble all pipe joints as tightly as practical, to prevent unscrewing from motor torque. Torque should be at least 10 pound feet per HP (2 meter-KG per KW).
❑ E. Set the pump far enough below the lowest pumping level to assure the pump inlet will always have at least the Net Positive Suction Head (NPSH) specified by the pump manufacturer. Pump should be at least 10 feet (3 meters) from the bottom of the well to allow for sediment build up.
❑ F. Check insulation resistance as pump/motor assembly is lowered into the well. Resistance may drop gradually as more cable enters the water, but any sudden drop indicates possible cable, splice or motor lead damage; see Page 39.

**9. After Installation**

- ❑ A. Check all electrical and water line connections and parts before starting the pump.
- ❑ B. Start the pump and check motor amps and pump delivery. If normal, continue to run the pump until delivery is clear. If three phase pump delivery is low, it may be running backward. Rotation may reversed (with power off) by interchanging any two motor lead connections to the power supply.
- ❑ C. Check three phase motors for current balance within 5% of average, using motor manufacturer instructions. Imbalance over 5% will cause higher motor temperatures and may cause overload trip, vibration, and reduced life.
- ❑ D. Verify that starting, running and stopping cause no significant vibration or hydraulic shocks.
- ❑ E. After at least 15 minutes running time, verify that pump output, electrical input, pumping level, and other characteristics are stable and as specified.

Date ______________________ Filled In By ______________________________________________

Notes____________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

_________________________________________________________________________________

# Submersible Motor Installation Record

RMA No. ____________

INSTALLER'S NAME ____________________________ OWNER'S NAME ____________________________________

ADDRESS ____________________________________ ADDRESS ____________________________________________

CITY __________________ STATE_____ ZIP________ CITY ____________________ STATE_____ ZIP____________

PHONE (____) _____________ FAX (____) _________ PHONE (____) _____________ FAX (____)______________

CONTACT NAME _______________________________ CONTACT NAME ___________________________________

WELL NAME/ID ________________________________ DATE INSTALLED _____________ DATE FAILED___________

WATER TEMPERATURE ________°F or ________°C

**MOTOR:**

Motor No. __________________ Date Code ____________________ HP ________ Voltage _________ Phase _________

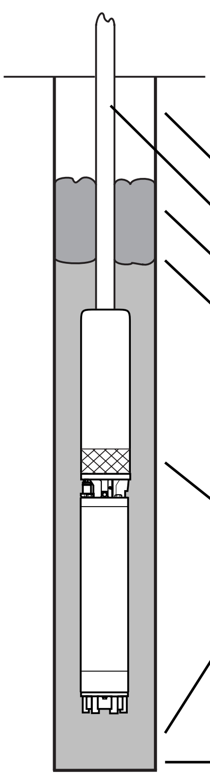
**PUMP:**

Manufacturer __________________ Model No. __________ Curve No. __________ Rating: ______ GPM@______ft. TDH

NPSH Required ____________ ft. NPSH Available__________ ft. Actual Pump Delivery__________GPM@ ______ PSI

Operating Cycle _________________ON (Min./Hr.) _________________ OFF (Min./Hr.) (Circle Min. or Hr. as appropriate)

YOUR NAME ______________________________________________________________ DATE ______/______/______



**WELL DATA:**

Total Dynamic Head _________________ft.

Casing Diameter____________________in.

Drop Pipe Diameter _________________in.

Static Water Level __________________ft.

Drawdown (pumping) Water Level_______ft.

Checkvalves at __________&__________&

__________&__________ft.

❑ Solid ❑ Drilled

Pump Inlet Setting __________________ft.

Flow Sleeve: ____No____ Yes, Dia. _____in.

Casing Depth______________________ft.

❑ Well Screen ❑ Perforated Casing

From______to_____ft. & ______to______ft.

Well Depth_________________________ft.

**TOP PLUMBING:**
Please sketch the plumbing after the well head (check valves, throttling valves, pressure tank, etc.) and indicate the setting of each device.

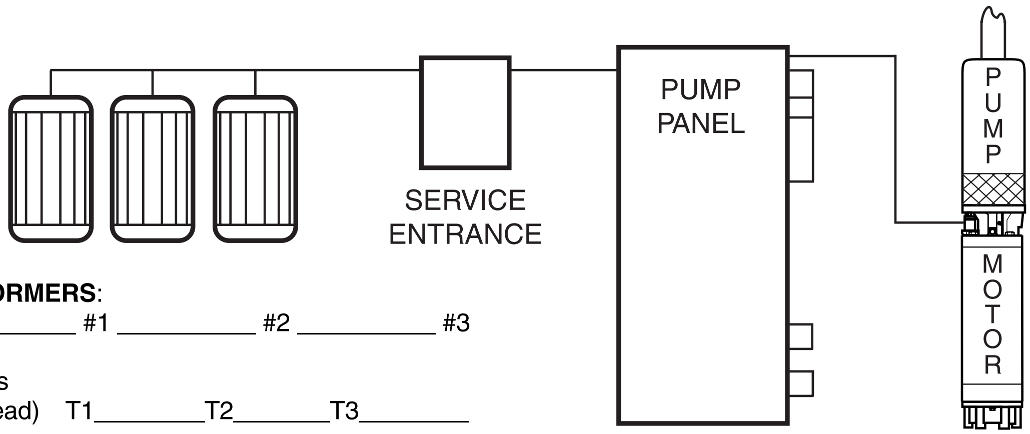
Form No. 2207 8/00

# Submersible Motor Installation Record

**POWER SUPPLY:**

Cable: Service Entrance to Control ____________ft.________ AWG/MCM ❑ Copper ❑ Aluminum ❑ Jacketed ❑ Individual Conductors

Cable: Control to Motor ____________ft.________ AWG/MCM ❑ Copper ❑ Aluminum ❑ Jacketed ❑ Individual Conductors




**TRANSFORMERS**:

KVA __________ #1 __________ #2 __________ #3

Initial Megs
(motor & lead) T1________T2_______T3________

Final Megs
(motor, lead & cable) T1______T2______T3______

**INCOMING VOLTAGE:**

No Load L1-L2______ L2-L3_______L1-L3_______
Full Load L1-L2______ L2-L3_______L1-L3_______

**RUNNING AMPS:**

HOOKUP 1:
Full Load L1______L2_______L3_______
%Unbalance______

HOOKUP 2:
Full Load L1______L2_______L3_______
%Unbalance______

HOOKUP 3:
Full Load L1______L2_______L3_______
%Unbalance______

Ground Wire Size ___________________AWG/MCM
DC Ground Current ________________________mA
Motor Surge Protection ❑ Yes ❑ No

**CONTROL PANEL:**

Panel Manufacturer_______________________________
Short Circuit Device
❑ Circuit Breaker Rating________Setting______
❑ Fuses Rating___________ Type___________
❑ Standard ❑ Delay

Starter Manufacturer_______________________________
Starter Size _______________________________
Type of Starter ❑ Full Voltage ❑ Autotransformer
❑ Other:___________Full Voltage in _____sec.

Heater Manufacturer_______________________________
Number______________Adjustable Set at ________amps.
Subtrol-Plus ❑ No ❑ Yes Registration No. __________
If yes, Overload Set? ❑ No ❑ Yes Set at _______amps.
Underload Set? ❑ No ❑ Yes Set at _______amps.

Controls are Grounded to:
❑ Well Head ❑ Motor ❑ Rod ❑ Power Supply

**VARIABLE FREQUENCY DRIVES:**

Manufacturer__________________ Model ______________ Output Frequency: _________ Hz Min _________ Hz Max

Cooling Flow at Min. Freq. ___________________________ Cooling Flow at Max. Freq.__________________________

Approved Overload: ❑ Built-in ________ ❑ External Model: (per above) ❑ Cables: (per above) Set Amps ___________

Start Time ____________sec. Stop Mode ❑ Coast __________sec. ❑ Ramp __________ sec.

❑ Output filter ___________ ❑ Reactor _______________% Make __________ Model ___________ ❑ None

**MAXIMUM LOAD AMPS**:

Drive Meter Input Amps Line 1 __________ Line 2 __________ Line 3 __________
Drive Meter Output Amps Line 1 __________ Line 2 __________ Line 3 __________
Test Ammeter Output Amps Line 1 __________ Line 2 __________ Line 3 __________
Test Ammeter Make ________________________ Model ________________________

# Submersible Motor Booster Installation Record

**Submersible Motor Booster Installation Record**

Date _______ /_______ / ________ Filled In By ____________________________________ RMA No. ___________________

**Installation**

Owner/User __________________________________________________________ Telephone (______) ______________________

Address ____________________________________________________City _________________ State ______ Zip __________

Installation Site, If Different _________________________________________________________________________________

Contact _____________________________________________________________ Telephone (______) ______________________

System Application___________________________________________________________________________________________

_____________________________________________________________________________________________________________

_____________________________________________________________________________________________________________

System Manufactured By__________________________________Model __________________ Serial No. ________________

System Supplied By______________________________________ City __________________ State ______ Zip __________

**Motor**

Model No. ________________ Serial No. ________________ Date Code _______

Horsepower _______ Voltage _______ ❑ Single Phase ❑ Three Phase Diameter _______ In.

Slinger Removed? ❑ Yes ❑ No Check Valve Plug Removed? ❑ Yes ❑ No

**Pump**

Manufacturer ________________ Model ________________ Serial No. ________________

Stages _______ Diameter _________ Flow Rate Of _________ GPM At ______TDH

Booster Case Internal Diameter _________ Construction ________________

**Controls and Protective Devices**

Subtrol? ❑ Yes ❑ No If Yes, Warranty Registration No.__________________________________________________

If Yes, Overload Set? ❑ Yes ❑ No ______ Set At __________________________________

Underload Sets? ❑ Yes ❑ No ______ Set At __________________________________

Reduced Voltage Starter? ❑Yes ❑ No If Yes, Type ________________________________________________________

Mfr. _______________ Setting ___________%Full Voltage In ________Seconds

Pump Panel? ❑ Yes ❑ No If Yes, Mfr. ________________________________Size ____________________

Magnetic Starter/Contactor Mfr. _____________________________ Model ___________________Size_______________

Heaters Mfr. _______________________ No. _____________ If Adjustable Set At _____________________________________

Fuses Mfr. ______________________ Size ____________ Type ____________________________________________________

Lightning/Surge Arrestor Mfr. __________________________ Model ___________________________________________________

Controls Are Grounded to ____________________ with No. _________Wire

Inlet Pressure Control ❑ Yes ❑ No If Yes, Mfr.________________ Model ________________ Setting________PSI

Inlet Flow Control ❑ Yes ❑ No If Yes, Mfr.________________ Model ________________Setting______ GPM

Outlet Pressure Control ❑ Yes ❑ No If Yes, Mfr.________________ Model ________________Setting________PSI

Outlet Flow Control ❑ Yes ❑ No If Yes, Mfr.________________ Model ________________Setting______ GPM

Water Temperature Control ❑ Yes ❑ No If Yes, Mfr.________________ Model ________________________________

Set At _________ °F Or ______ °C Located _________________________________________

# Submersible Motor Booster Installation Record

**Insulation Check**

Initial Megs: Motor & Lead Only Black_________ Yellow________ Red_________
Installed Megs: Motor, Lead, & Cable Black_________ Yellow________ Red_________

**Voltage To Motor**

Non-Operating: B-Y__________ Y-R__________ R-B_________
At Rated Flow of __________GPM B-Y__________ Y-R__________ R-B_________
At Open Flow ____________GPM B-Y__________ Y-R__________ R-B_________

**Amps To Motor**

At Rated Flow of __________GPM Black_________ Yellow________ Red_________
At Open Flow ____________GPM Black_________ Yellow________ Red_________
At Shut Off* Black_________ Yellow________ Red_________
*Do **NOT** run at Shut Off more than two (2) minutes.
Inlet Pressure __________PSI Outlet Pressure __________PSI Water Temperature _______°F or _______°C

Warranty on three phase motors is void unless Subtrol or proper quick trip ambient compensated protection is used on all three (3) motor lines.

**If you have any questions or problems, call the Franklin Electric Toll-Free Hot Line: 1-800-348-2420**

Comments:_______________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________
________________________________________________________________________________________

**Please sketch the system**

## Three Phase Starter Diagrams

Three phase combination magnetic starters have two distinct circuits: a power circuit and a control circuit.

The power circuit consists of a circuit breaker or fused line switch, contacts, and overload heaters connecting incoming power lines L1, L2, L3 and the three phase motor.

The control circuit consists of the magnetic coil, overload contacts and a control device such as a pressure switch. When the control device contacts are closed, current flows through the magnetic contactor coil, the contacts close, and power is applied to the motor. Hands-Off-Auto switches, start timers, level controls and other control devices may also be in series in the control circuit.

### Line Voltage Control

This is the most common type of control encountered. Since the coil is connected directly across the power lines, L1 and L2, the coil must match the line voltage.

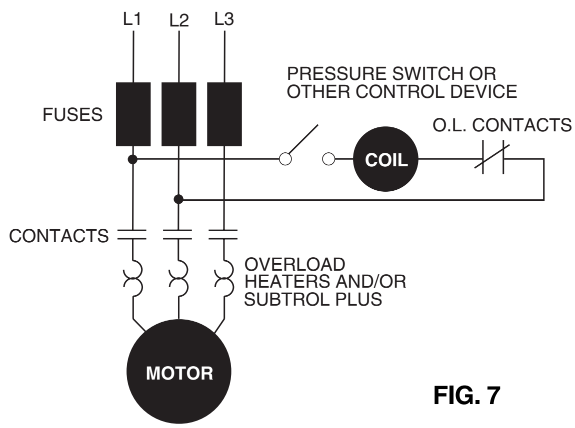



FIG. 7

### Low Voltage Transformer Control

This control is used when it is desirable to operate push buttons or other control devices at some voltage lower than the motor voltage. The transformer primary must match the line voltage and the coil voltage must match the secondary voltage of the transformer.

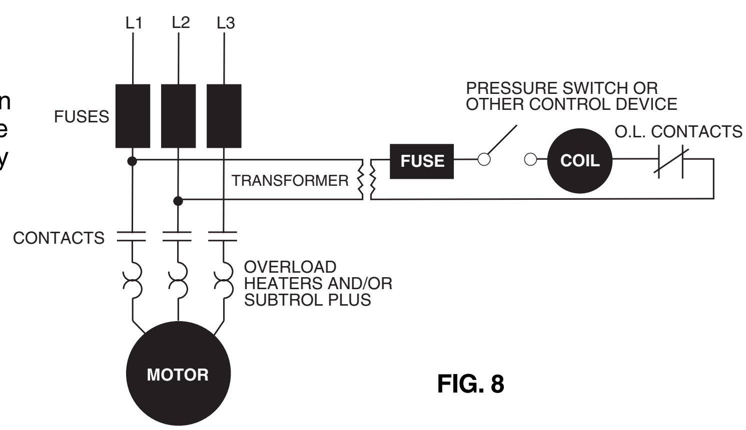



FIG. 8

### External Voltage Controls

Control of a power circuit by a lower circuit voltage can also be obtained by connecting to a separate control voltage source. The coil rating must match the control voltage source, such as 115 or 24 volts.

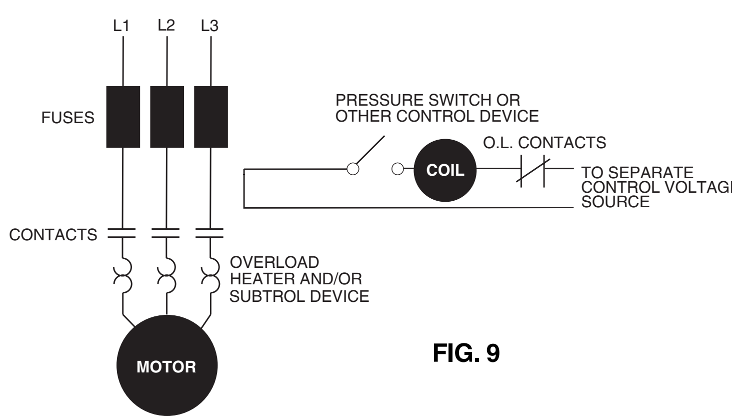



FIG. 9

## Three Phase Power Unbalance

A full three phase supply is recommended for all three phase motors, consisting of three individual transformers or one three phase transformer. So-called “open” delta or wye connections using only two transformers can be used, but are more likely to cause problems, such as poor performance, overload tripping or early motor failure due to current unbalance.

Transformer rating should be no smaller than listed in Table 4 for supply power to the motor alone.

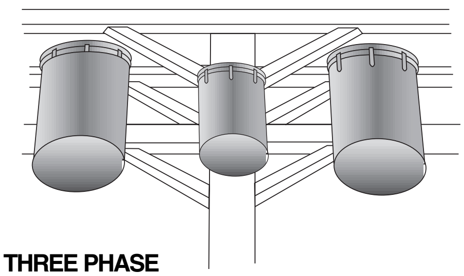


**FIG. 10 FULL THREE PHASE**

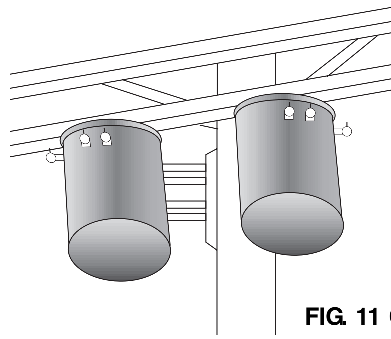


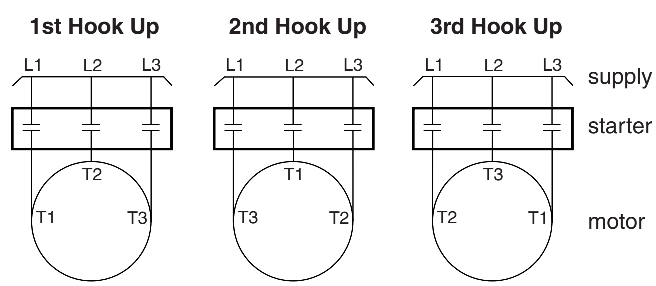
**FIG. 11 OPEN DELTA**

## Checking And Correcting Rotation And Current Unbalance

1. Established correct motor rotation by running in both directions. Change rotation by exchanging any two of the three motor leads. The rotation that gives the most water flow is always the correct rotation.
2. After correct rotation has been established, check the current in each of the three motor leads and calculate the current unbalance as explained in 3 below.

   If the current unbalance is 2% or less, leave the leads as connected.

   If the current unbalance is more than 2%, current readings should be checked on each leg using each of three possible hook-ups. Roll the motor leads across the starter in the same direction to prevent motor reversal.
3. To calculate percent of current unbalance:
   A. Add the three line amps values together.
   B. Divide the sum by three, yielding average current.
   C. Pick the amp value which is furthest from the average current (either high or low).
   D. Determine the difference between this amp value (furthest from average) and the average.
   E. Divide the difference by the average. Multiply the result by 100 to determine percent of unbalance.
4. Current unbalance should not exceed 5% at service factor load or 10% at rated input load. If the unbalance cannot be corrected by rolling leads, the source of the unbalance must be located and corrected. If, on the three possible hookups, the leg farthest from the average stays on the same power lead, most of the unbalance is coming from the power source. However, if the reading farthest from average moves with the same motor lead, the primary source of unbalance is on the “motor side” of the starter. In this instance, consider a damaged cable, leaking splice, poor connection, or faulty motor winding.




**EXAMPLE:**

| 1st Hook Up | 2nd Hook Up | 3rd Hook Up |
|---|---|---|
| T1 = 50 amps | T3 = 51 amps | T2 = 50 amps |
| T2 = 49 amps | T1 = 46 amps | T3 = 48 amps |
| + T3 = 51 amps | + T2 = 53 amps | + T1 = 52 amps |
| Total = 150 amps | Total = 150 amps | Total = 150 amps |
| $\frac{150}{3}$ = 50 amps | $\frac{150}{3}$ = 50 amps | $\frac{150}{3}$ = 50 amps |
| 50 - 49 = 1 amp | 50 - 46 = 4 amps | 50 - 48 = 2 amps |
| $\frac{1}{50}$ = .02 or 2% | $\frac{4}{50}$ = .08 or 8% | $\frac{2}{50}$ = .04 or 4% |

**Phase designation of leads for CCW rotation viewing shaft end.**

To reverse rotation, interchange any two leads.

Phase 1 or “A”- Black, T1, or U1

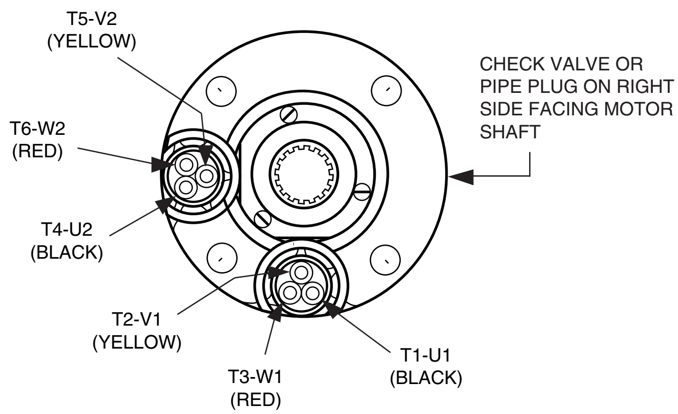
Phase 2 or “B”- Yellow, T2, or V1

Phase 3 or “C”- Red, T3, or W1

**NOTICE:** Phase 1, 2 and 3 may not be L1, L2 and L3.

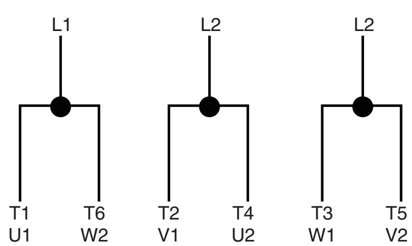
## Three Phase Motor Lead Identification

### 90° Lead Spacing

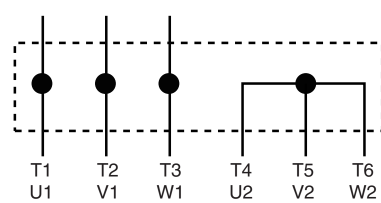



### Line Connections — Six Lead Motors

Connections for across-the-line starting, running, and any reduced voltage starting except WYE-DELTA type starters.




WYE-DELTA starters connect the motor as shown below during starting, then change to the running connection shown at the left.




Each motor lead is numbered with two markers, one near each end. To reverse rotation. Interchange any two line connections.

## Phase Converters

There are a number of different types of phase converters available. Each generates three phase power from a single phase power line.

In all phase converters, the voltage balance is critical to current balance. Although some phase converters may be well balanced at one point on the system-operating curve, submersible pumping systems often operate at differing points on the curve as water levels and operating pressures fluctuate. Other converters may be well balanced at varying loads, but their output may vary widely with fluctuations in the input voltage.

The following guidelines have been established for submersible installations to be warrantable when used with a phase converter.

1. Limit pump loading to rated horsepower. Do not load into motor service factor.
2. Maintain at least 3 ft/sec. flow past the motor. Use a flow sleeve when necessary.
3. Use time delay fuses or circuit breakers in pump panel. Standard fuses or circuit breakers do not provide secondary motor protection.
4. Subtrol-Plus may be used with electro mechanical type phase converters, however special connections are required. Consult Subtrol-Plus Manual for connections of receiver and lighting arrestor.
5. Subtrol-Plus will not work with electronic solid state phase converters.
6. Current unbalance must not exceed 10%.

## Reduced Voltage Starters

All Franklin three phase submersible motors are suitable for full voltage starting. Under this condition the motor speed goes from zero to full speed within a half second or less. The load current goes from zero to locked rotor amps, about 5 to 7 times running amps, and drops to running amps at full speed. This may dim lights, cause momentary voltage dips to other electrical equipment, and shock load power distribution transformers.

Power companies may require reduced voltage starters to limit this voltage dip if started “directly on line”. There are also times when it may be desirable to reduce motor starting torque. This lessens the stress on shafts, couplings, and castings, as well as the supporting discharge piping. A “strong” voltage supply and a small cable voltage drop produces higher starting torque. Reduced voltage starters are used to reduce starting current or torque, and slow the immediate acceleration of the water on start up to control upthrust and water hammer.

With maximum recommended cable length, there is a 5% voltage drop in the cable, and there will be about 20% reduced starting current and about 36% reduction in starting torque compared to having rated voltage at the motor. This may be enough reduction in starting current so that reduced voltage starters may not be required.

Standard three phase motors have three line leads so only resistance, autotransformer, or solid state reduced voltage starters may be used. The autotransformer type is preferred over resistance and solid state types because it draws lower line current for the same starting torque.

Wye-Delta starters are used with six lead Wye-Delta motors. All Franklin 6" and 8" three phase motors are available in six lead Wye-Delta construction. Consult the factory for details and availability. Part winding starters are not usable with Franklin Electric submersible motors.

When reduced voltage starters are used, it is recommended that the motor be supplied with at least 55% of rated voltage to ensure adequate starting torque.

Most autotransformers starters have 65% and 85% taps. Setting the taps on these starters depends on the percentage of the maximum allowable cable length used in the system. If the cable length is less than 50% of the maximum allowable, either the 65% or the 80% taps may be used. When the cable length is more than 50% of allowable, the 80% tap should be used.

Solid state reduced voltage starters may be used with submersibles, but are not usable with Subtrol-Plus.

**Both electromechanical and solid state starters have adjustable time delays for starting. Typically they are preset at 30 seconds. They must be set so the motor is at full voltage within TWO TO THREE SECONDS MAXIMUM to prevent overload trip and unnecessary heating.**

Open transition starters, which momentarily interrupt power during the starting cycle, are not recommended. Only closed transition starters, which have no interruption of power during the start cycle, should be used.

## Inline Booster Pump Systems

Franklin submersible motors are acceptable for booster pump (canned) applications providing the following conditions are taken into consideration in the system design.

1. **Horizontal Operation:** Horizontal operation is acceptable as long as the pump transmits thrust to the motor and the entire assembly is supported sufficiently to prevent binding stresses.
2. **Motor Support:** The motor support assembly must not restrict the flow of cooling water around the full diameter of the motor. The motor supports must be on the motor endbell castings, and not on the motor shell.
3. **Motor Alterations:** On 6” and 8” motors, the sand slinger should be removed. The pipe plug covering the check valve should be removed from Ni-resist and 316 SS motors.
4. **Controls:** Franklin Subtrol-Plus is strongly recommended for all large submersibles. If Subtrol-Plus is not employed, properly sized ambient compensated quick-trip overloads must be utilized. In addition, a surge arrestor should be installed on all systems and properly grounded.
5. **Wiring:** Franklin’s lead assemblies are sized for submerged operation and may not be adequate for use in open air. Any wiring not submerged must comply with Franklin’s cable charts.
6. **Water Temperature:** The temperature of the water should be monitored at the inlet to each booster. When temperatures exceed 86°F (30°C), motor derating is required.
7. **Inlet Pressure:** The inlet pressure on each booster should be monitored and not be allowed below the pump’s specified Net Positive Suction Head Requirements (NPSHR). If NPSHR is unknown, at least 20 PSI should be maintained at all times. **At no time should the pressure surrounding the motor be less than one atmosphere.**
8. **Discharge Flow:** The flow rate for each pump should not be allowed to drop below the minimum required maintaining cooling flow velocities. Pressure relieving valves should be employed to prevent running the pump at shut-off.
9. **Discharge Pressure:** The discharge pressure should be great enough to prevent upthrust.
10. **Can Flooding:** An air bleeder valve must be employed on the booster can so that flooding may be accomplished prior to booster start-up. Once flooding is complete, the booster should be started

## Inline Booster Pump Systems (continued)

as quickly as possible to minimize the chance of upthrust. Water should never be forced through the booster can (more than momentarily) without the pump running as failure due to upthrust may occur.

**IMPORTANT NOTES:**

1. **High Pressure Tests:** Motors intended for booster applications where the pressure exceeds 500 PSI must be special ordered from the factory.
2. **Starting:** Reduced voltage starting may be employed. This will reduce upthrust on start, starting current, and mechanical stresses created by the motor's high starting torque. Reduced voltage starters, if used should accelerate the motor to full speed within two seconds. Note: Solid state reduced voltage starters are not compatible with Subtrol-Plus.

## Variable Speed Submersible Pump Operation, Inverter Drives

Franklin three phase submersible motors are operable from variable frequency inverter drives when applied within guidelines shown below. These guidelines are based on present Franklin information for inverter drives, lab tests and actual installations, and must be followed for warranty to apply to inverter drive installations. Franklin two-wire and three-wire single phase submersible motors are not recommended for variable speed operation.

**Warning: There is a potential shock hazard from contact with insulated cables from a PWM drive to the motor. This hazard is due to high frequency voltage content of a PWM drive output.**

**Load Capability:** Pump load should not exceed motor nameplate service factor amps at rated voltage and frequency.

**Volts/Hz:** Use motor nameplate volts and frequency for the drive base settings. Many drives have means to increase efficiency at reduced pump speeds by lowering motor voltage. This is the preferred operating mode.

**Motor Current Limits:** Load no higher than motor nameplate service factor amps. For 50 Hz ratings, nameplate maximum amps are rated amps. See Overload Protection below.

**Carrier Frequency:** Applicable to PWM drives only. These drives often allow selection of the carrier frequency. Use a low carrier frequency.

**Voltage Rise-time or dV/dt:** Limit the voltage peak at the motor to 1000V and the rise time to no more than 2 μsec. See filters and reactors.

**Motor Overload:** Follow the Franklin guidelines listed in the Application Installation Maintainance (AIM) Manual.

**Protection:** Drives with built-in motor protection will meet Franklin's quick-trip overload requirements. The ultimate trip (not the setting) must not exceed 115% of nameplate maximum amps in any line.

**Subtrol-Plus:** Franklin's Subtrol-Plus protection systems ARE NOT USABLE on VFD installations.

**Frequency Range:** Continuous between 30 and 60 Hz. Consult factory for operations above 60 Hz.

**Start and Stop:** One second maximum ramp-up and ramp-down times between stopped and 30 Hz. Stopping by coast-down is preferable.

**Successive Starts:** Allow 60 seconds before restarting.

**Filters or Reactors:** Required if (1) Voltage is 380 or greater and (2) Drive uses IGBT or BJT switches (rise-times < 2 msec) and (3) Cable from drive to motor is more than 50 ft. A low-pass filter is preferable. Filters or reactors should be selected in conjunction with the drive manufacturer and must be specifically designed for VFD operation.

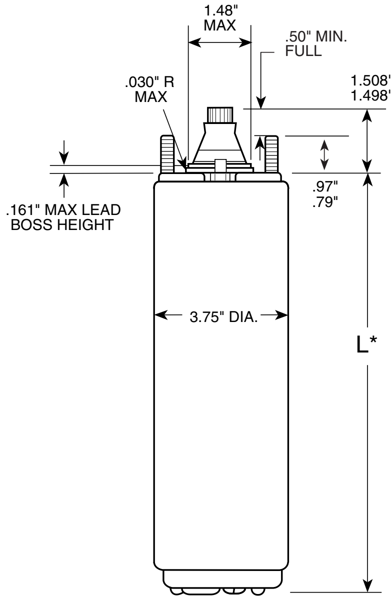
**Cable Lengths :** Per Franklin's cable tables.

**Motor Cooling Flow:** The flow rate past the motor at rated nameplate motor frequency (Hz) must meet Franklin's minimum flow requirements. 4" .25 ft./sec. and 6" and 8" .5 ft./sec.

# Installation - All Motors

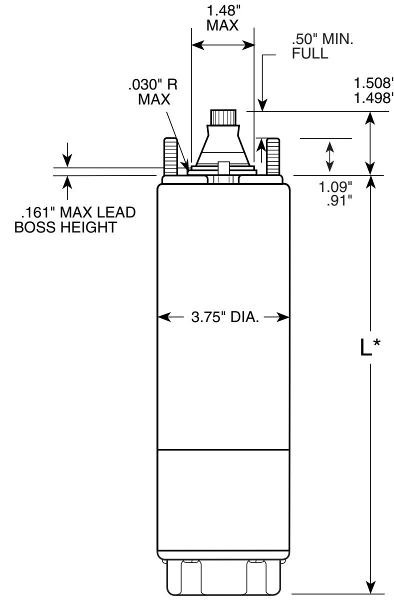
## 4" Super Stainless — Dimensions

### (Standard Water Well)



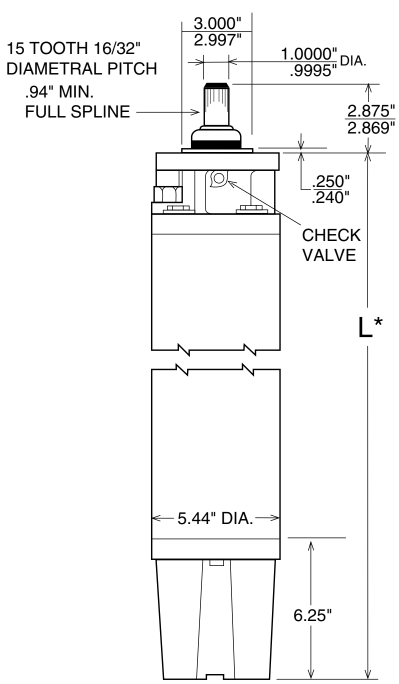

## 4" High Thrust — Dimensions

### (Standard Water Well)



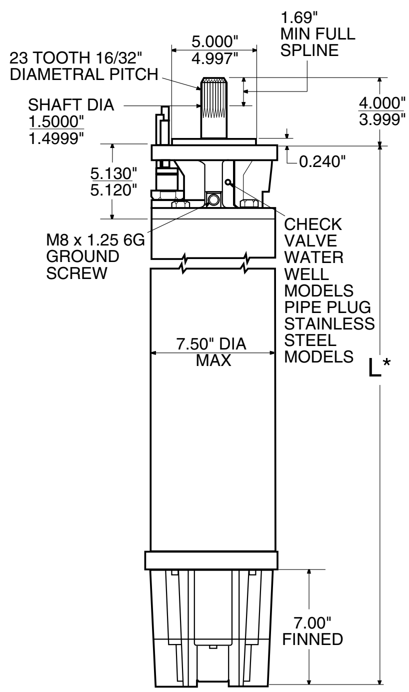

## 6"— Dimensions

### (Standard Water Well)

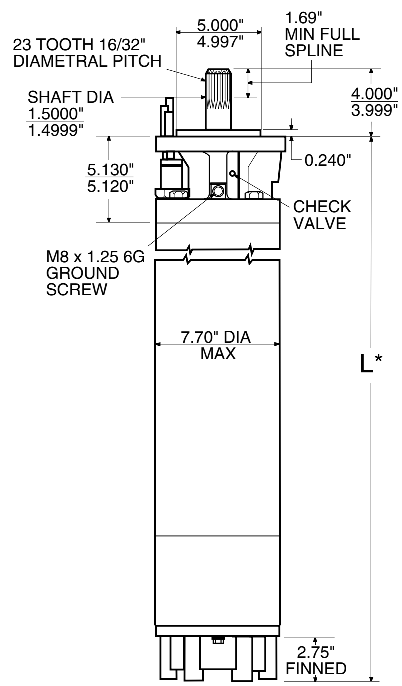



## 8"— Dimensions

### (Standard Water Well)




40 to 100 HP




125 to 200 HP

*** Motor lengths and shipping weights are available on Franklin Electric's web page (www.franklin-electric.com) or by calling Franklin's submersible hotline (800-348-2420).**

## Tightening Motor Lead Connector Jam Nut

4" Motors - 15 to 20 ft-lb. (20 to 27 N-m)
6" Motors - 50 to 60 ft-lb. (68 to 81 N-m)
8” Motors with: 1-3/16" to 1-5/8" Jam Nut - 50 to 60 ft-lb. (68 to 81 N-m)
8" Motors with 4 Screw Clamp Plate: Apply increasing torque to the screws equally in a criss-cross pattern until 80 to 90 in-lb. (9.0 to 10.2 N-m) is reached.

A motor lead assembly should not be reused. A new lead assembly should be used whenever one is removed from the motor, because rubber set and possible damage from removal may prevent proper resealing of the old lead.

**All motors returned for warranty consideration must have the lead returned with the motor.**

## Pump to Motor Coupling

Assemble coupling with non-toxic FDA approved waterproof grease such as Mobile FM102, Texaco CYGNUS2661, or approved equivalent. This prevents abrasives from entering the spline area and prolongs spline life.

## Shaft Height and Free End Play

**Table 34**

| Motor | Normal Shaft Height | | Dimension Shaft Height | | Free End Play | |
|---|---|---|---|---|---|---|
| | | | | | Min. | Max. |
| 4" | 1 1/2" | 38.1 mm | 1.508" / 1.498" | 38.30 / 38.05 mm | .010" / .25 mm | .045" / 1.14 mm |
| 6" | 2 7/8" | 73.0 mm | 2.875" / 2.869" | 73.02 / 72.88 mm | .030" / .75 mm | .050" / 1.25 mm |
| 8" Type 1 | 4" | 101.5 mm | 4.000" / 3.990" | 101.60 / 101.35 mm | .008" / .20 mm | .020" / .50 mm |
| 8" Type 2 | 4" | 101.5 mm | 4.000" / 3.990" | 101.60 / 101.35 mm | .035" / .89 mm | .060" / 1.52 mm |
| 8" Type 2.1 | 4" | 101.5 mm | 4.000" / 3.990" | 101.60 / 101.35 mm | .030" / .75 mm | .080" / 2.03 mm |

If the height, measured from the pump-mounting surface of the motor, is low and/or end play exceeds the limit, the motor thrust bearing is possibly damaged, and should be replaced.

## Submersible Leads and Cables

A common question is why motor leads are smaller than specified in Franklin’s cable charts.

The leads are considered a part of the motor and actually are a connection between the large supply wire and the motor winding. The motor leads are short and there is virtually no voltage drop across the lead.

In addition, the lead assemblies **operate under water**, while at least part of the supply cable must **operate in air.** Lead assemblies running under water operate cooler.

**CAUTION: Lead assemblies on submersible motors are suitable only for use in water and may overheat and cause failure if operated in air.**

## Splicing Submersible Cables

When the drop cable must be spliced or connected to the motor leads, it is necessary that the splice be watertight. This splice can be made with commercially available potting, heat shrink splicing kits, or by careful tape splicing.

Tape splicing should use the following procedure.

A) Strip individual conductor of insulation only as far as necessary to provide room for a stake type connector. Tubular connectors of the staked type are preferred. If connector outside diameter (OD) is not as large as cable insulation, build up this area with rubber electrical tape.

B) Tape individual joints with rubber electrical tape, using two layers, with the first layer extending two inches beyond each end of the conductor insulation end, and the second layer extending two inches beyond the ends of the first layer. Wrap tightly, eliminating air spaces as much as possible.

C) Tape over the rubber electrical tape with #33 Scotch electrical tape, (3M) or equivalent, using two layers as in step “B” and making each layer overlap the end of the preceding layer by at least two inches.

In the case of a cable with three conductors encased in a single outer sheath, tape individual conductors as described, staggering joints.

Total thickness of tape should be no less than the thickness of the conductor insulation.

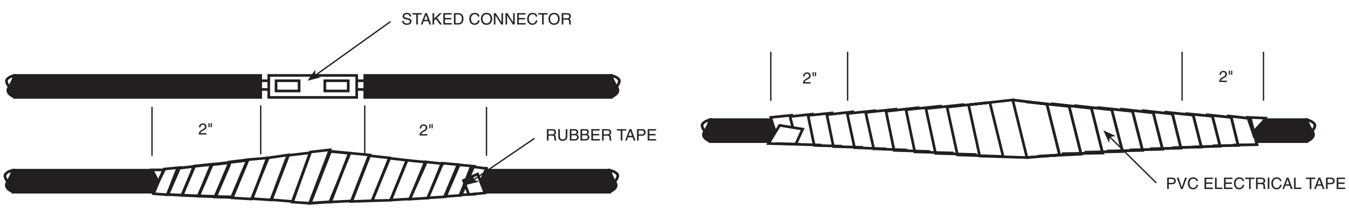



**FIG. 12**

## System Trouble Shooting

### Motor Does Not Start

| Possible Cause | Checking Procedures | Corrective Action |
|---|---|---|
| **A.** No power or incorrect voltage. | Check voltage at line terminals. The voltage must be ± 10% of rated voltage. | Contact power company if voltage is incorrect. |
| **B.** Fuses blown or circuit breakers tripped. | Check fuses for recommended size and check for loose, dirty or corroded connections in fuse receptacle. Check for tripped circuit breakers. | Replace with proper fuse or reset circuit breakers. |
| **C.** Defective pressure switch. | Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage. | Replace pressure switch or clean points. |
| **D.** Control box malfunction. | For detailed procedure, see pages 40-41. | Repair or replace. |
| **E.** Defective wiring | Check for loose or corroded connections or defective wiring. | Correct faulty wiring or connections. |
| **F.** Bound pump. | Check for misalignment between pump and motor or a sand bound pump. Amp readings will be 3 to 6 times higher than normal until the overload trips. | Pull pump and correct problem. Run new installation until the water clears. |
| **G.** Defective cable or motor. | For detailed procedure, see pages 38-40. | Repair or replace. |

### Motor Starts Too Often

| | | |
|---|---|---|
| **A.** Pressure switch. | Check setting on pressure switch and examine for defects. | Reset limit or replace switch. |
| **B.** Check valve - stuck open. | Damaged or defective check valve will not hold pressure. | Replace if defective. |
| **C.** Waterlogged tank. | Check air charge. | Repair or replace. |
| **D.** Leak in system. | Check system for leaks. | Replace damaged pipes or repair leaks. |

## System Trouble Shooting

### Motor Runs Continuously

| Possible Cause | Checking Procedures | Corrective Action |
|---|---|---|
| **A.** Pressure switch. | Check switch for welded contacts. Check switch adjustments. | Clean contacts, replace switch, or adjust setting. |
| **B.** Low water level in well. | Pump may exceed well capacity. Shut off pump, wait for well to recover. Check static and drawdown level from well head. | Throttle pump output or reset pump to lower level. Do not lower if sand may clog pump. |
| **C.** Leak in system. | Check system for leaks. | Replace damaged pipes or repair leaks. |
| **D.** Worn pump. | Symptoms of worn pump are similar to those of drop pipe leak or low water level in well. Reduce pressure switch setting, if pump shuts off worn parts may be the fault. | Pull pump and replace worn parts. |
| **E.** Loose coupling or broken motor shaft. | Check for loose coupling or damaged shaft. | Replace worn or damaged parts. |
| **F.** Pump screen blocked. | Check for clogged intake screen. | Clean screen and reset pump depth. |
| **G.** Check valve stuck closed. | Check operation of check valve. | Replace if defective. |
| **H.** Control box malfunction. | See pages 40-41 for single phase. | Repair or replace. |

### Motor Runs But Overload Protector Trips

| | | |
|---|---|---|
| **A.** Incorrect voltage. | Using voltmeter, check the line terminals. Voltage must be within ± 10% of rated voltage. | Contact power company if voltage is incorrect. |
| **B.** Overheated protectors. | Direct sunlight or other heat source can raise control box temperature causing protectors to trip. The box must not be hot to touch. | Shade box, provide ventilation or move box away from source. |
| **C.** Defective control box. | For detailed procedures, see pages 40-41. | Repair or replace. |
| **D.** Defective motor or cable. | For detailed procedures, see pages 38-40. | Repair or replace. |
| **E.** Worn pump or motor. | Check running current. See pages 13 & 21-23. | Replace pump and/or motor. |

### Table 38 Preliminary Tests - All Sizes Single and Three Phase

| "Test" | Procedure | What it Means |
|---|---|---|
| **Insulation Resistance** | 1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter.<br>2. Set the scale lever to R X 100K and set the ohmmeter on zero.<br>3. Connect one ohmmeter lead to any one of the motor leads and the other lead to the metal drop pipe. If the drop pipe is plastic, connect the ohmmeter lead to ground. | 1. If the ohms value is normal (Table 39), the motor is not grounded and the cable insulation is not damaged.<br>2. If the ohms value is below normal, either the windings are grounded or the cable insulation is damaged. Check the cable at the well seal as the insulation is sometimes damaged by being pinched. |
| **Winding Resistance** | 1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter.<br>2. Set the scale lever to R X 1 for values under 10 ohms. For values over 10 ohms, set the scale lever to R X 10. "Zero" the ohmmeter.<br>3. On 3-wire motors measure the resistance of yellow to black (Main winding) and yellow to red (Start winding).<br>On 2-wire motors measure the resistance from line to line.<br>Three phase motors measure the resistance line to line for all three combinations. | 1. If all ohms values are normal (Tables 13, 21, 22 & 23), the motor windings are neither shorted nor open, and the cable colors are correct<br>2. If any one value is less than normal, the motor is shorted.<br>3. If any one ohm value is greater than normal, the winding or the cable is open, or there is a poor cable joint or connection.<br>4. If some ohms values are greater than normal and some less on single phase motors, the leads are mixed. See Page 40 to verify cable colors. |

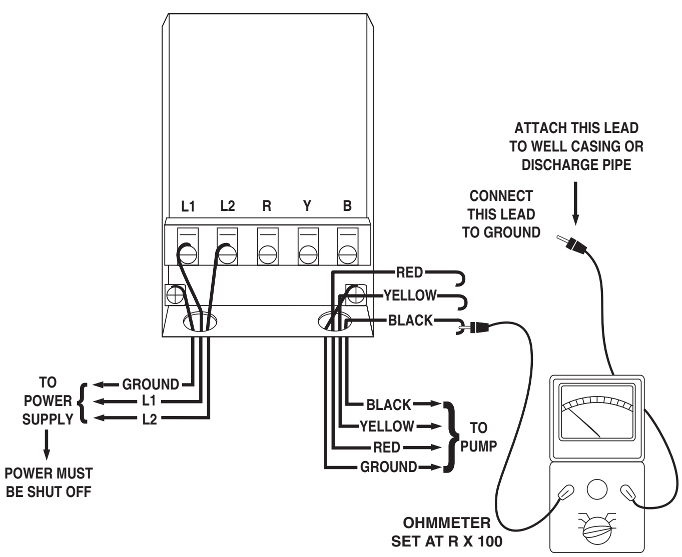



**FIG. 13**

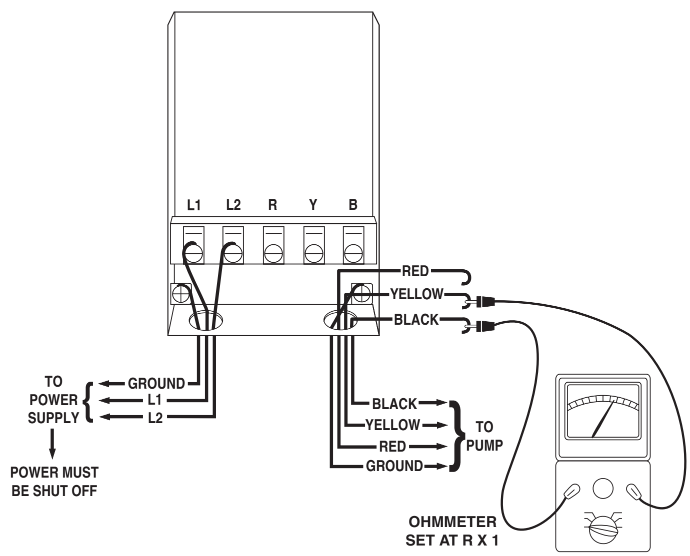



**FIG. 14**

## Insulation Resistance Readings

**Table 39 Normal Ohm and Megohm Values Between All Leads and Ground**

| Condition of Motor and Leads | Ohm Value | Megohm Value |
|---|---|---|
| A new motor (without drop cable). | 20,000,000 (or more) | 20 (or more) |
| A used motor which can be reinstalled in well. | 10,000,000 (or more) | 10 (or more) |
| **Motor in well. Readings are for drop cable plus motor.** | | |
| New motor. | 2,000,000 (or more) | 2 (or more) |
| Motor in good condition. | 500,000 - 2,000,000 | .5 - 2 |
| Insulation damage, locate and repair. | Less than 500,000 | Less than .5 |

Insulation resistance varies very little with rating. Motors of all HP, voltage, and phase ratings have similar values of insulation resistance.

Table 39 is based on readings taken with a megohmmeter with a 500V DC output. Readings may vary using a lower voltage ohmmeter, consult Franklin Electric if readings are in question.

## Resistance of Drop Cable (Ohms)

The values below are for copper conductors. If aluminum conductor drop cable is used, the resistance will be higher. To determine the actual resistance of the aluminum drop cable, divide the ohm readings from this chart by 0.61. This chart shows total resistance of cable from control to motor and back.

### Winding Resistance Measuring

When measured as shown in FIG 14, Page 38, motor resistance should fall within the values in Tables 13, 21, 22 & 23. When measured through the drop cable, the resistance of the drop cable as determined from the chart below, must be subtracted from the ohmmeter reading to get the winding resistance of the motor.

**DC Resistance in Ohms per 100ft. of Wire (Two conductors) @ 50°F**

| AWG or MCM Wire Size (Copper) | 14 | 12 | 10 | 8 | 6 | 4 | 3 | 2 |
|---|---|---|---|---|---|---|---|---|
| Ohms | 0.544 | 0.338 | 0.214 | 0.135 | 0.082 | 0.052 | 0.041 | 0.032 |

| 1 | 1/0 | 2/0 | 3/0 | 4/0 | 250 MCM | 300 MCM | 350 MCM | 400 MCM | 500 MCM | 600 MCM | 700 MCM |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.026 | 0.021 | 0.017 | 0.013 | 0.010 | 0.0088 | 0.0073 | 0.0063 | 0.0056 | 0.0044 | 0.0037 | 0.0032 |

## Identification Of Cables When Color Code Is Unknown (SINGLE PHASE 3-WIRE UNITS)

If the colors on the individual drop cables cannot be found with an ohmmeter, measure:

Cable 1 to Cable 2
Cable 2 to Cable 3
Cable 3 to Cable 1

Find the highest resistance reading.

The lead not used in the highest reading is the yellow lead.

Use the yellow lead and each of the other two leads to get two readings:

Highest is the red lead.
Lowest is the black lead.

**EXAMPLE:**

**The ohmmeter readings were:**

Cable 1 to Cable 2—6 ohms
Cable 2 to Cable 3—2 ohms
Cable 3 to Cable 1— 4 ohms

The lead not used in the highest reading (6 ohms) was
Cable 3—Yellow

From the yellow lead, the highest reading (4 ohms) was
To Cable 1—Red

From the yellow lead, the lowest reading (2 ohms) was
To Cable 2—Black

## Single Phase Control Boxes

**Checking and Repairing Procedures (Power On)**

**WARNING :** Power must be on for these tests. Do not touch any live parts.

**A. VOLTAGE MEASUREMENTS**

**Step 1. Motor Off**

1. Measure voltage at L1 and L2 of pressure switch or line contactor.
2. Voltage Reading: Should be ±10% of motor rating.

**Step 2. Motor Running**

1. Measure voltage at load side of pressure switch or line contactor with pump running.
2. Voltage Reading: Should remain the same except for slight dip on starting. Excessive voltage drop can be caused by loose connections, bad contacts, ground faults, or inadequate power supply.
3. Relay chatter is caused by low voltage or ground faults.

**B. CURRENT (AMP) MEASUREMENTS**

1. Measure current on all motor leads.
2. Amp Reading: Current in red lead should momentarily be high, then drop within one second to values on Page 13. This verifies relay or solid state relay operation. Current in black and yellow leads should not exceed values on Page 13.
3. Relay or switch failures will cause red lead current to remain high and overload tripping.
4. Open run capacitor(s) will cause amps to be higher than normal in the black and yellow motor leads and lower than normal in the red motor lead.
5. A bound pump will cause locked rotor amps and overloading tripping.
6. Low amps may be caused by pump running at shutoff, worn pump, or stripped splines.
7. Failed start capacitor or open switch/relay are indicated if the red lead current is not momentarily high at starting.

**CAUTION :** The tests in this manual for components such as capacitors, relays, and QD switches should be regarded as indicative and not as conclusive. For example, a capacitor may test good (not open, not shorted) but may have lost some of its capacitance and may no longer be able to perform its function.

To verify proper operation of QD switches or relays, refer to operational test procedure described above in Section B-2.

## Ohmmeter Tests

**QD, Solid State Control Box (Power Off)**

**A. START CAPACITOR AND RUN CAPACITOR IF APPLICABLE (CRC)**

1. Meter Setting: R x 1,000.
2. Connections: Capacitor terminals.
3. Correct meter reading: Pointer should swing toward zero, then back to infinity.

**B. Q.D. (BLUE) RELAY**

**Step 1. Triac Test**

1. Meter setting: R x 1,000.
2. Connections: Cap and B terminal.
3. Correct meter reading: Infinity for all models.

**Step 2, Coil Test**

1. Meter Setting: R x 1.
2. Connections: L1 and B.
3. Correct meter reading: Zero ohms for all models.

**C. POTENTIAL (VOLTAGE) RELAY**

**Step 1. Coil Test**

1. Meter setting: R x 1,000.
2. Connections: #2 & #5.
3. Correct meter readings: For 115 Volt Boxes
   .7-1.8 (700 to 1,800 ohms).
   For 230 Volt Boxes
   4.5-7.0 (4,500 to 7,000 ohms).

**Step 2. Contact Test**

1. Meter setting: R x 1.
2. Connections: #1 & #2.
3. Correct meter reading: Zero for all models.

**D. SOLID STATE SWITCH**

**Step 1. Triac Test**

1. Meter Setting: R x 1,000.
2. Connections: R (Start) terminal and orange lead on start switch.
3. Correct meter reading: Infinity for all models.

**Step 2. Coil Test**

1. Meter Setting: R x 1.
2. Connections: Y (Common) and L2.
3. Correct meter reading: Zero ohms for all models.

## Ohmmeter Tests

**Integral Horsepower Control Box (Power Off)**

**A. OVERLOADS** (Push Reset Buttons to make sure contacts are closed.)

1. Meter Setting: R x 1.
2. Connections: Overload terminals.
3. Correct meter reading: Less than 0.5 ohms.

**B. CAPACITOR** (Disconnect leads from one side of each capacitor before checking.)

1. Meter Setting: R x 1,000.
2. Connections: Capacitor terminals.
3. Correct meter reading: Pointer should swing toward zero, then drift back to infinity, except for capacitors with resistors which will drift back to 15,000 ohms.

**C. RELAY COIL** (Disconnect lead from Terminal #5)

1. Meter Setting: R x 1,000.
2. Connections: #2 & #5.
3. Correct meter readings: 4.5-7.0 (4,500 to 7,000 ohms) for all models.

**D. RELAY CONTACT** (Disconnect lead from Terminal #1)

1. Meter Setting: R x 1.
2. Connections: #1 & #2.
3. Correct meter reading: Zero ohms for all models.

**E. CONTACTOR COIL** (Disconnect lead from one side of coil)

1. Meter Setting: R x 100.
2. Connections: Coil terminals.
3. Correct meter reading: 180 to 1,400 ohms.

**F. CONTACTOR CONTACTS**

1. Meter Setting: R X 1.
2. Connections: L1 & T1 or L2 & T2.
3. Manually close contacts.
4. Correct meter reading: Zero ohms.

**CAUTION :** The tests in this manual for components such as capacitors, relays, and QD switches should be regarded as indicative and not as conclusive. For example, a capacitor may test good (not open, not shorted) but may have lost some of its capacitance and may no longer be able to perform its function.

To verify proper operation of QD switches or relays, refer to operational test procedure described on Page 40, Section B-2.

**Table 42 QD Control Box Parts 60 Hz**

| HP | Volts | Control Box Model Number | QD (Blue) Relay | Start Capacitor | MFD | Volts | Run Capacitor | MFD | Volts |
|---|---|---|---|---|---|---|---|---|---|
| 1/3 | 115 | 2801024915 | 223415905 | 275464125 | 159-191 | 110 | | | |
| | 230 | 2801034915 | 223415901 | 275464126 | 43-53 | 220 | | | |
| 1/2 | 115 | 2801044915 | 223415906 | 275464201 | 250-300 | 125 | | | |
| | 230 | 2801054915 | 223415902 | 275464105 | 59-71 | 220 | | | |
| | 230 | 2824055015 **(CRC)** | 223415912 | 275464126 | 43-53 | 220 | 156132101 | 15 | 370 |
| 3/4 | 230 | 2801074915 | 223415903 | 275464118 | 86-103 | 220 | | | |
| | 230 | 2824075015 **(CRC)** | 223415913 | 275464105 | 59-71 | 220 | 156132102 | 23 | 370 |
| 1 | 230 | 2801084915 | 223415904 | 275464113 | 105-126 | 220 | | | |
| | 230 | 2824085015 **(CRC)** | 223415914 | 275464118 | 86-103 | 220 | 156132102 | 23 | 370 |

**NOTE 1:** Control boxes supplied with QD relays are designed to operate on 230 volt systems. For 208 volt systems or where line voltage is between 200 volts and 210 volts use the next larger cable size, or use a boost transformer to raise the voltage.

**NOTE 2:** Voltage relays kits for 115 volts (305102 901) and 230 volts (305102 902) will replace current, voltage or QD relays, and solid state switches.

**QD Capacitor Replacement Kits**

| Capacitor Number | Kit |
|---|---|
| 275 464 105 | 305 207 905 |
| 275 464 113 | 305 207 913 |
| 275 464 118 | 305 207 918 |
| 275 464 125 | 305 207 925 |
| 275 464 126 | 305 207 926 |
| 156 132 101 | 305 203 907 |
| 156 132 102 | 305 203 908 |

**QD Overload Kits 60 Hz**

| HP | Volts | Kit (1) |
|---|---|---|
| 1/3 | 115 | 305100 901 |
| 1/3 | 230 | 305100 902 |
| 1/2 | 115 | 305100 903 |
| 1/2 | 230 | 305100 904 |
| 3/4 | 230 | 305100 905 |
| 1 | 230 | 305100 906 |

(1) For Control Boxes with model numbers that end with 915.

**QD Relay Replacement Kits**

| QD Relay Number | Kit |
|---|---|
| 223 415 901 | 305 101 901 |
| 223 415 902 | 305 101 902 |
| 223 415 903 | 305 101 903 |
| 223 415 904 | 305 101 904 |
| 223 415 905 | 305 101 905 |
| 223 415 906 | 305 101 906 |
| 223 415 912 (CRC) | 305 105 901 |
| 223 415 913 (CRC) | 305 105 902 |
| 223 415 914 (CRC) | 305 105 903 |

**Table 43 Integral Horsepower Control Box Parts 60 Hz**

| Motor Size | Motor Rating HP | Control Box (1) Model No. | Capacitors Part No. (2) | Capacitors Mfd. | Capacitors Volts | Capacitors Qty. | Overload (2) Part No. | Relay (3) Part No. | Contactor (2) Part No. |
|---|---|---|---|---|---|---|---|---|---|
| 4" | 1 1/2 Standard | 282 3008 110 | 275 464 113 S | 105-126 | 220 | 1 | 275 411 107 | 155 031 102 | |
| | | | 155 328 102 R | 10 | 370 | 1 | | | |
| 4" | 2 Standard | 282 3018 110 | 275 464 113 S | 105-126 | 220 | 1 | 275 411 107 S | 155 031 102 | |
| | | | 155 328 103 R | 20 | 370 | 1 | 275 411 113 M | | |
| 4" | 2 Deluxe | 282 3018 310 | 275 464 113 S | 105-126 | 220 | 1 | 275 411 107 S | 155 031 102 | 155 325 102 L |
| | | | 155 328 103 R | 20 | 370 | 1 | 275 411 113 M | | |
| 4" | 3 Standard | 282 3028 110 | 275 463 111 S | 208-250 | 220 | 1 | 275 411 108 S | 155 031 102 | |
| | | | 155 327 102 R | 35 | 370 | 1 | 275 411 115 M | | |
| 4" | 3 Deluxe | 282 3028 310 | 275 463 111 S | 208-250 | 220 | 1 | 275 411 108 S | 155 031 102 | 155 325 102 L |
| | | | 155 327 102 R | 35 | 370 | 1 | 275 411 115 M | | |
| 4" & 6" | 5 Standard | 282 1138 110 | 275 468 119 S | 270-324 | 330 | 1 | 275 411 102 S | 155 031 102 | |
| | | | 155 327 101 R | 30 | 370 | 2 | 275 406 102 M | | |
| 4" & 6" | 5 Deluxe | 282 1138 310 or 282 1139 310 | 275 468 119 S | 270-324 | 330 | 1 | 275 411 102 S | 155 031 102 | 155 326 101 L |
| | | | 155 327 101 R | 30 | 370 | 2 | 275 406 102 M | | |
| 6" | 7 1/2 Standard | 282 2019 210 | 275 468 119 S | 270-324 | 330 | 1 | 275 411 102 S | 155 031 601 | |
| | | | 275 468 118 S | 216-259 | 330 | 1 | 275 406 122 M | | |
| | | | 155 327 109 R | 45 | 370 | 1 | | | |
| 6" | 7 1/2 Deluxe | 282 2019 310 | 275 468 119 S | 270-324 | 330 | 1 | 275 411 102 S | 155 031 601 | 155 326 101 L |
| | | | 275 468 118 S | 216-259 | 330 | 1 | 275 406 121 M | | |
| | | | 155 327 109 R | 45 | 370 | 1 | | | |
| 6" | 10 Standard | 282 2029 210 | 275 468 119 S | 270-324 | 330 | 1 | 275 406 103 S | 155 031 601 | |
| | | | 275468 120 S | 350-420 | 330 | 1 | | | |
| | | | 155 327 102 R | 35 | 370 | 2 | 155 409 101 M | | |
| 6" | 10 Deluxe | 282 2029 310 | 275 468 119 S | 270-324 | 330 | 1 | 275 406 103 S | 155 031 601 | 155 326 102 L |
| | | | 275468 120 S | 350-420 | 330 | 1 | | | |
| | | | 155 327 102 R | 35 | 370 | 2 | 155 409 101 M | | |
| 6" | 15 Deluxe | 282 2039 310 | 275 468 120 S | 350-420 | 330 | 2 | 275 406 103 S | 155 031 601 | 155 429 102 L |
| | | | 155 327 109 R | 45 | 370 | 3 | 155 409 102 M | | |

**FOOTNOTES:**

(1) Lightning arrestors 150 814 902 are suitable for all control boxes.

(2) S = Start, M = Main, L = Line, Deluxe = Control box with line contactors

(3) For 208V systems or where line voltage is between 200V and 210V a low voltage relay is required. Use relay part 155 031 601 in place of 155 031 102 or 155 031 602 in place of 155 031 601. Use the next larger cable size than specified in 230V table. Boost transformers per Page 14 are an alternative to special relays and cable.

### Integral HP Capacitor Replacement Kits

| Capacitor Number | Kit |
|---|---|
| 275 463 111 | 305 206 911 |
| 275 464 113 | 305 207 913 |
| 275 468 117 | 305 208 917 |
| 275 468 118 | 305 208 918 |
| 275 468 119 | 305 208 919 |
| 155 327 101 | 305 203 901 |
| 155 327 102 | 305 203 902 |
| 155 327 109 | 305 203 909 |
| 155 328 102 | 305 204 902 |
| 155 328 103 | 305 204 903 |

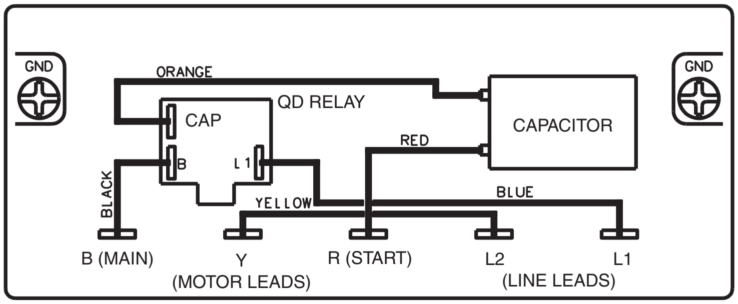
### Integral HP Overload Replacement Kits

| Overload Number | Kit |
|---|---|
| 275 406 102 | 305 214 902 |
| 275 406 103 | 305 214 903 |
| 275 406 121 | 305 214 921 |
| 275 406 122 | 305 214 922 |
| 275 411 102 | 305 215 902 |
| 275 411 107 | 305 215 907 |
| 275 411 108 | 305 215 908 |
| 275 411 113 | 305 215 913 |
| 275 411 115 | 305 215 915 |

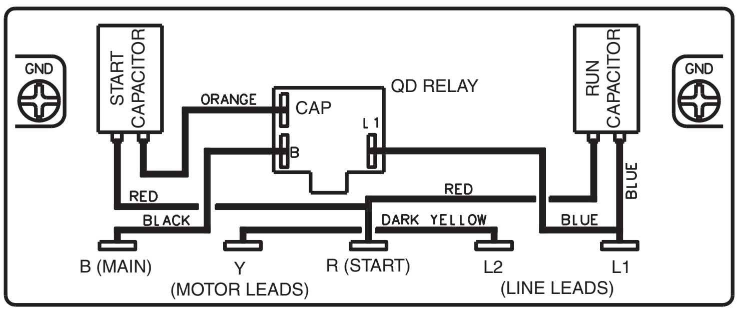
### Integral HP Voltage Relay Replacement Kits

| Relay Number | Kit |
|---|---|
| 155 031 102 | 305 213 902 |
| 155 031 601 | 305 213 961 |

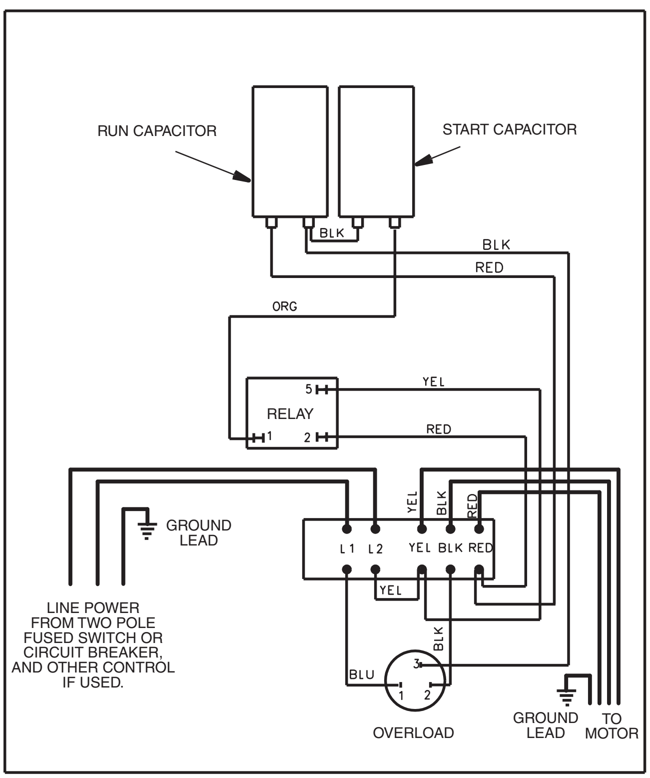
## Control Box Wiring Diagrams



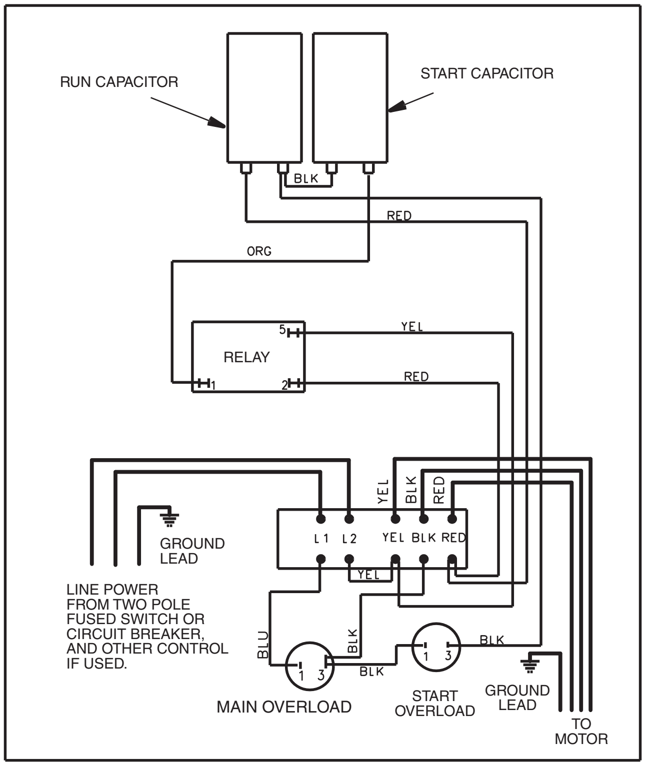

**⅓ - 1 HP QD RELAY**
280 10_ 4915
Sixth digit depends on HP



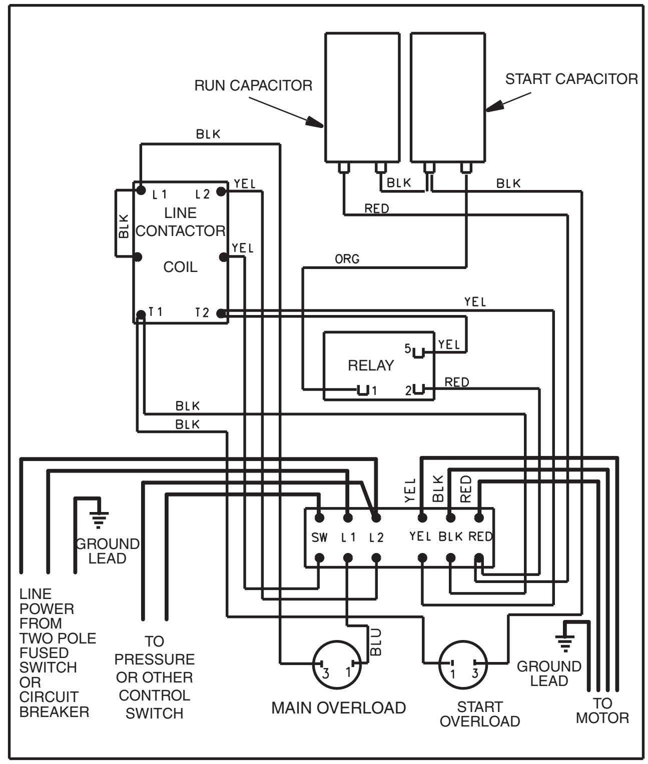

**½ - 1 HP CRC QD RELAY**
282 40_ 5015
Sixth digit depends on HP



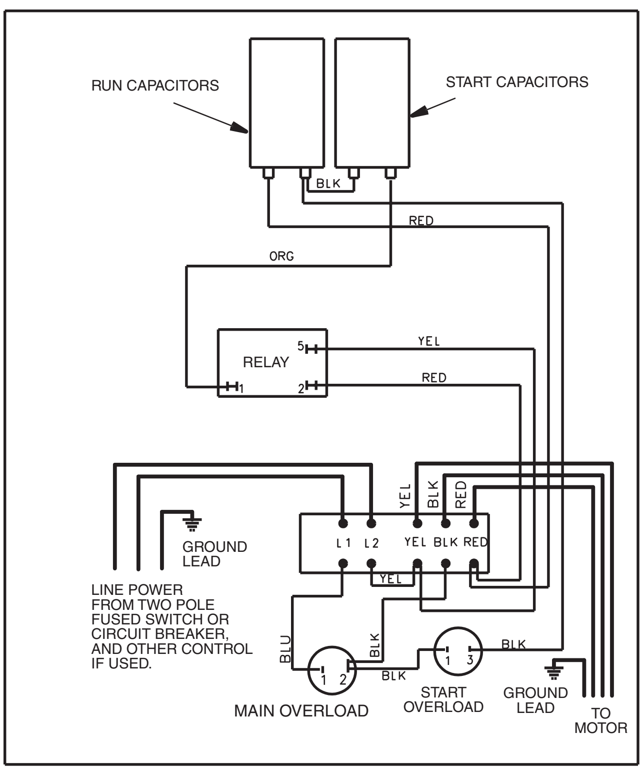

**1½ HP**
282 300 8110



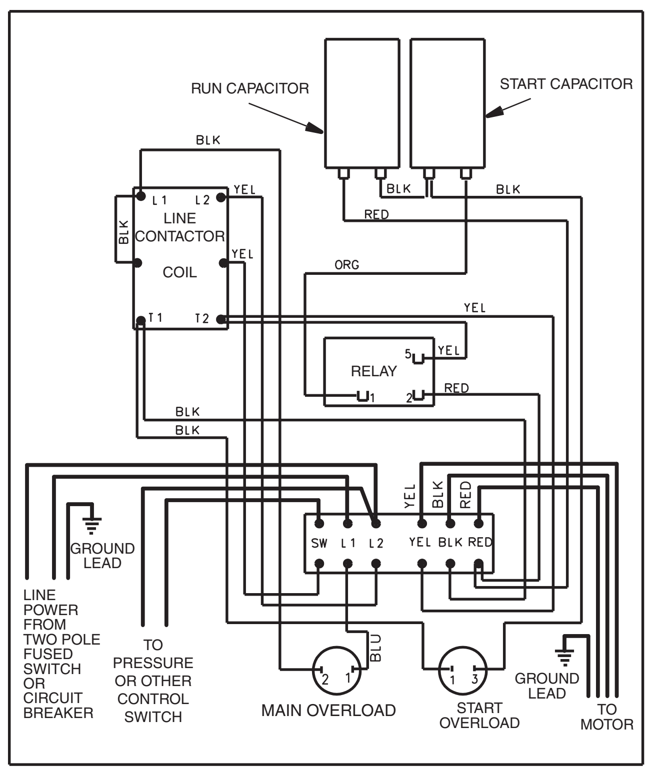

**2 HP STANDARD**
282 301 8110



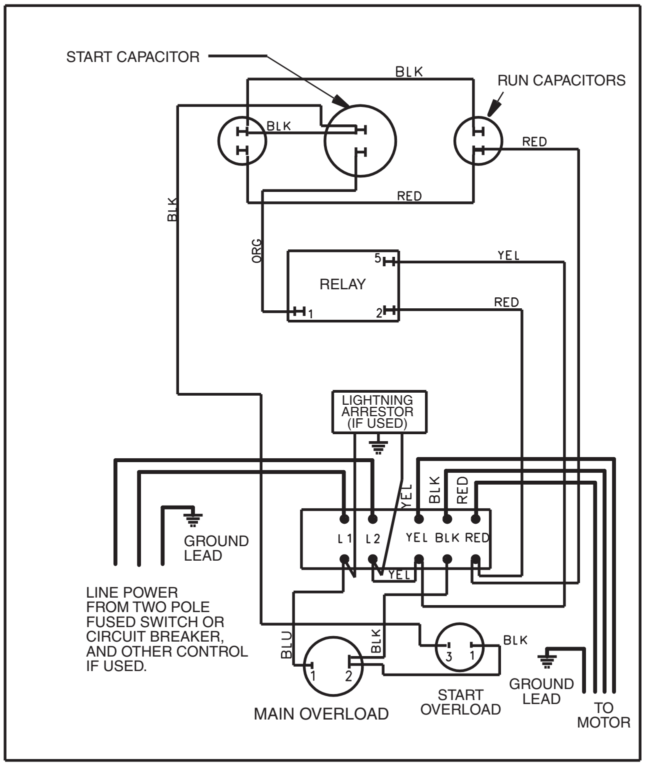

**2 HP DELUXE**
282 301 8310



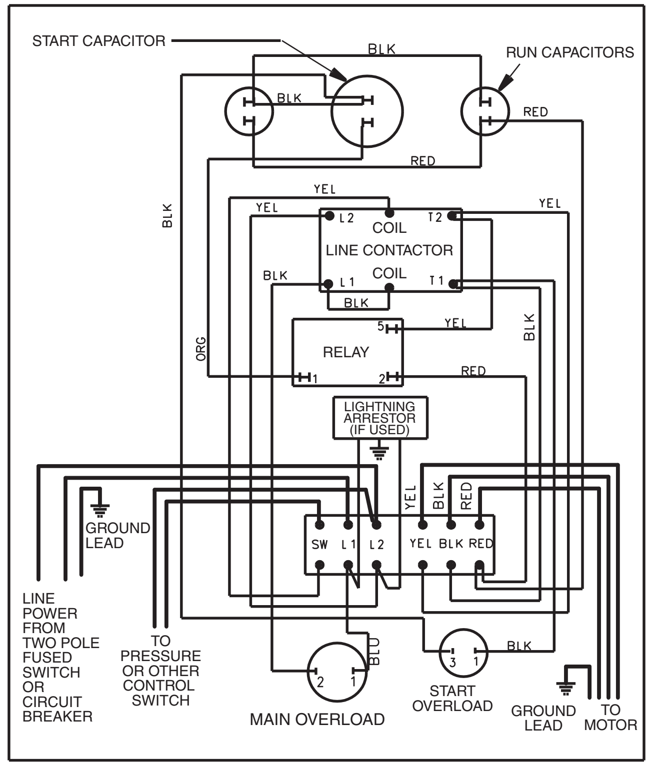

**3 HP STANDARD**
282 302 8110



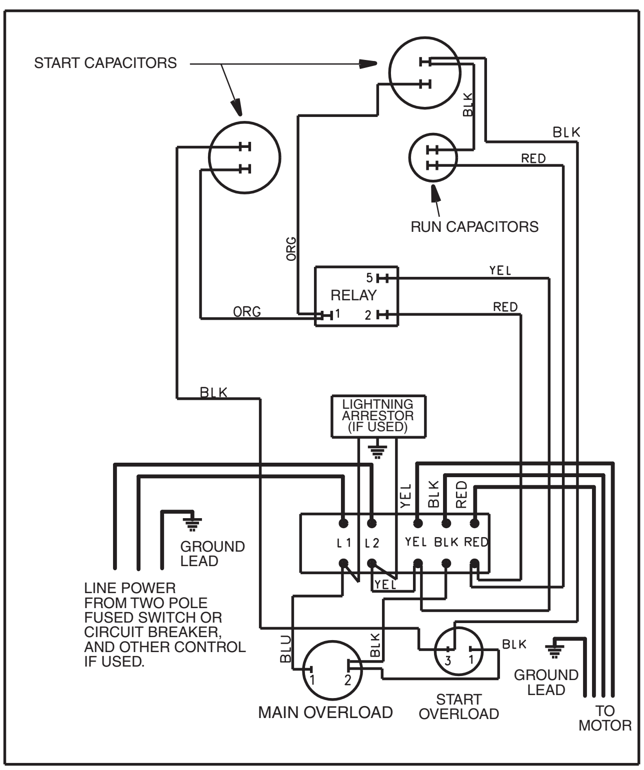

**3 HP DELUXE**
282 302 8310



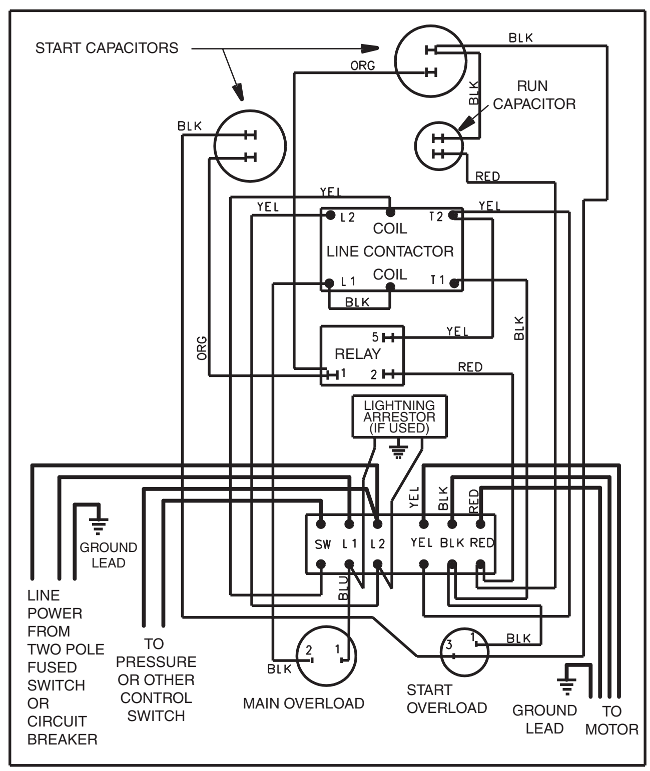

**5 HP STANDARD**
282 113 8110



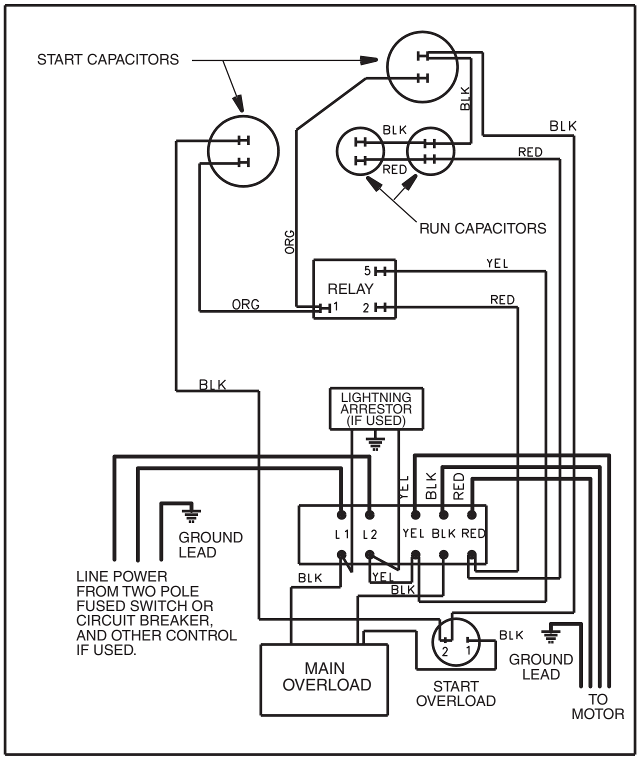

**5 HP DELUXE**
282 113 8310 or 282 113 9310




**7½ HP STANDARD**
282 201 9210

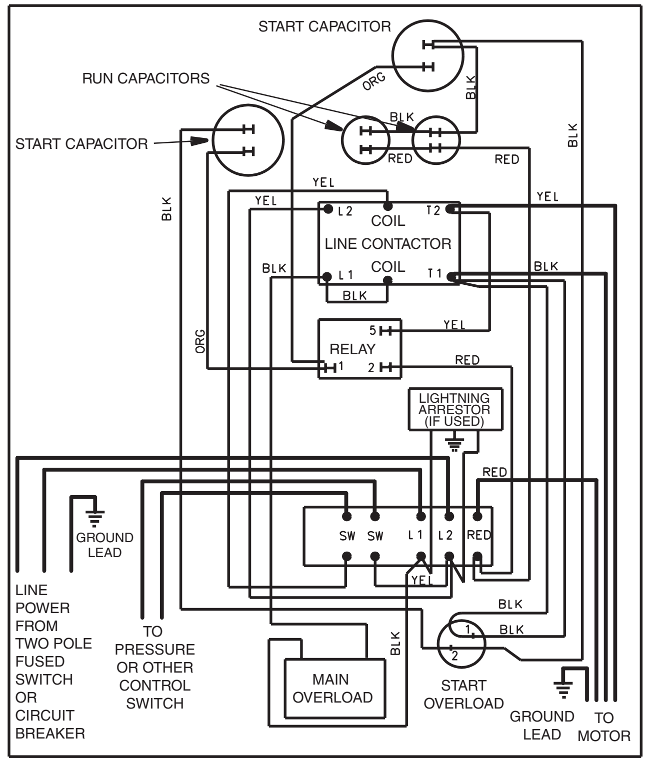



**7½ HP DELUXE**
282 201 9310



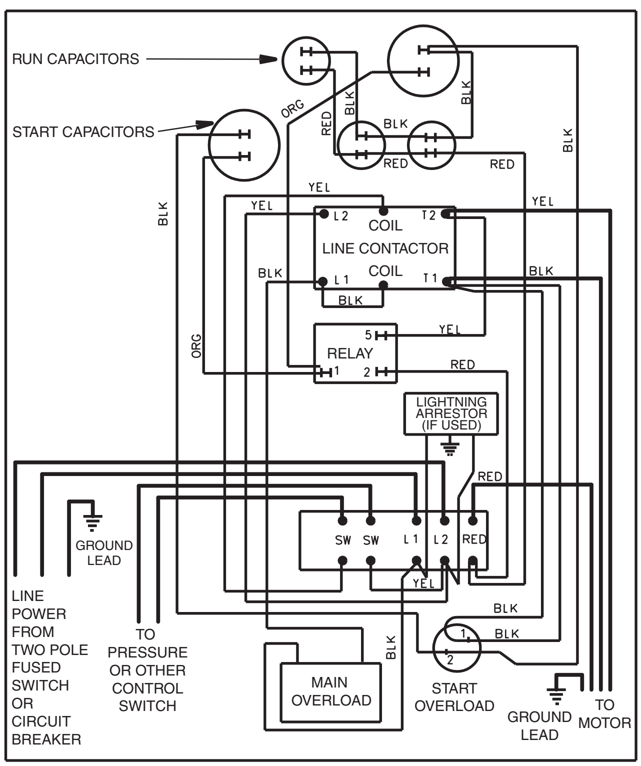

**10 HP STANDARD**

282 202 9210




**10 HP DELUXE**

282 202 9310




**15 HP DELUXE**

282 203 9310

## Pumptec-Plus

Pumptec-Plus is a pump/motor protection device designed to work on any 230V single phase induction motor (PSC, CSCR, CSIR, and split phase) ranging in size from 1/2 to 5 horsepower. Pumptec-Plus uses a micro-computer to continuously monitor motor power and line voltage to provide protection against dry well, water logged tank, high and low voltage and mud or sand clogging.

**Pumptec-Plus - Trouble Shooting During Installation**

| Symptom | Possible Cause | Solution |
|---|---|---|
| **Unit Appears Dead (No Lights)** | No Power to Unit | Check wiring. Power supply voltage should be applied to L1 and L2 terminals of the Pumptec-Plus.<br>In some installations the pressure switch or other control device is wired to the input of the Pumptec-Plus. Make sure this switch is closed. |
| **Flashing Yellow Light** | Unit Needs To Be Calibrated | Pumptec-Plus is calibrated at the factory so that it will overload on most pump systems when the unit is first installed. This overload condition is a reminder that the Pumptec-Plus unit requires calibration before use. See step 7 of the installation instructions. |
| | Miscalibrated | Pumptec-Plus should be calibrated on a full recovery well with the maximum water flow. Flow restrictors are not recommended. |
| **Flashing Yellow Light During Calibration** | Two-Wire Motor | Step C of the calibration instructions indicate that a flashing green light condition will occur 2 to 3 seconds after taking the SNAPSHOT of the motor load. On some two-wire motors the yellow light will flash instead of the green light. Press and release the reset button. The green should start flashing. |
| **Flashing Red and Yellow Lights** | Power Interruption | During the installation of Pumptec-Plus power may be switched on and off several times. If power is cycled more than four times within a minute Pumptec-Plus will trip on rapid cycle. Press and release the reset button to restart the unit. |
| | Float Switch | A bobbing float switch may cause the unit to detect a rapid cycle condition on any motor or an overload condition on two wire motors. Try to reduce water splashing or use a different switch. |
| **Flashing Red Light** | High Line Voltage | The line voltage is over 253 volts. Check line voltage. Report high line voltage to the power company. |
| | Unloaded Generator | If you are using a generator the line voltage may become too high when the generator unloads. Pumptec-Plus will not allow the motor to turn on again until the line voltage returns to normal. Over voltage trips will also occur if line frequency drops too far below 60 Hz. |
| **Solid Red Light** | Low Line Voltage | The line voltage is below 207 volts. Check line voltage. |
| | Loose Connections | Check for loose connections which may cause voltage drops. |
| | Loaded Generator | If you are using a generator the line voltage may become too low when the generator loads. Pumptec-Plus will trip on undervoltage if the generator voltage drops below 207 volts for more than 2.5 seconds. Undervoltage trips will also occur if the line frequency rises too far above 60 Hz. |

## Pumptec-Plus

### Pumptec-Plus - Trouble Shooting After Installation

| Symptom | Possible Cause | Solution |
|---|---|---|
| **Solid Yellow Light** | Dry Well | Wait for the automatic restart timer to time out. During the time out period, the well should recover and fill with water. If the automatic reset timer is set to the manual position, then the reset button must be pressed to reactivate the unit. |
| | Blocked Intake | Clear or replace pump intake screen. |
| | Blocked Discharge | Remove blockage in plumbing. |
| | Check Valve Stuck | Replace check valve. |
| | Broken Shaft | Replace broken parts. |
| | Severe Rapid Cycling | Machine gun rapid cycling can cause an underload condition. See flashing red and yellow lights section below. |
| | Worn Pump | Replace worn pump parts and recalibrate. |
| **Yellow Flashing Light** | Stalled Motor | Repair or replace motor. Pump may be sand or mud locked. |
| | Float Switch | A bobbing float switch can cause two-wire motors to stall. Arrange plumbing to avoid splashing water. Replace float switch. |
| | Ground Fault | Check insulation resistance on motor and control box cable. |
| **Solid Red Light** | Low Line Voltage | The line voltage is below 207 volts. Pumptec-Plus will try to restart the motor every two minutes until line voltage is normal. |
| | Loose Connections | Check for excessive voltage drops in the system electrical connections (i.e. circuit breakers, fuse clips, pressure switch, and Pumptec-Plus L1 and L2 terminals). Repair Connections. |
| **Flashing Red Light** | High Line Voltage | The line voltage is over 253 volts. Check line voltage. Report high line voltage to the power company. |
| **Flashing Red and Yellow Lights** | Rapid Cycle | The most common cause for the rapid cycle condition is a waterlogged tank. Check for a ruptured bladder in the water tank. Check the air volume control or snifter valve for proper operation. Check setting on the pressure switch and examine for defects. |
| | Leaky Well System | Replace damaged pipes or repair leaks. |
| | Stuck Check Valve | Failed valve will not hold pressure. Replace Valve. |
| | Float Switch | Press and release the reset button to restart the unit. A bobbing float switch may cause the unit to detect a rapid cycle condition on any motor or an overload condition on two wire motors. Try to reduce water splashing or use a different switch. |

## CP Water System

The Franklin Electric CP (Constant Pressure) Water System is a variable-speed water system that utilizes a variable-speed drive system to deliver water at a constant pressure.

**WARNING:**
Serious or fatal electrical shock may result from failure to connect the motor, CP Water Controller, metal plumbing and all other metal near the motor or cable to the power supply ground terminal using wire no smaller than motor cable wires. To reduce the risk of electrical shock, disconnect power before working on or around the water system. Capacitors inside the CP Water Controller can still hold a lethal voltage even after power has been removed. Allow 10 minutes for dangerous internal voltage to discharge. Do not use motor in swimming areas.

### CP Water System Troubleshooting

Should an application or system problem occur, a built-in diagnostics will protect the system. The “FAULT” light on the front of the CP Water Controller will flash a given number of times indicating the nature of the fault. In some cases, the system will shut itself off until corrective action is taken. Fault codes and their corrective actions are listed below.

| # of Flashes | Fault | Possible Cause | Corrective Action |
|---|---|---|---|
| 1 | Motor underload | Overpumped or dry well.<br>Worn pump.<br>Broken motor shaft.<br>Blocked pump screen. | Wait for well to recover and automatic restart timer to time out. If the problem does not correct, check motor and pump. See description of "smart reset" in CP Water installation manual. |
| 2 | Undervoltage | Low line voltage. | Check for loose connections. Check line voltage. Report low voltage to the power company. Unit will start automatically when proper power is supplied. |
| 3 | Locked pump | Motor/pump misaligned.<br>Sand bound pump. | Cycle input power*. On power up, unit will attempt to free a locked pump. If unsuccessful, check the motor and pump. |
| 4 | Rapid cycling (unit still runs) | Waterlogged tank. | With no water pressure, check air pressure in tank. Pressure should be 10-15 PSI below CP Water pressure setting. |
| 5 | Open circuit | Loose connections.<br>Defective motor or cable. | Check motor wiring. Make certain all connections are tight. Make certain proper motor is installed. Cycle input power* to reset. |
| 6 | Short circuit | Defective motor or cable. | Check motor wiring. |
| 7 | Overheat | High ambient temperature.<br>Direct sunlight.<br>No water flow through the unit. | This fault automatically resets when temperature returns to a safe level. |
| 8 | Internal sensor fault | | Cycle input power*. If problem persists, replace CP Water Controller. |

*"Cycle input power" means turn the power off for 5 seconds and then back on again.

## QD Pumptec and Pumptec

QD Pumptec and Pumptec are load sensing devices that monitor the load on submersible pump/motors. If the load drops below a preset level for a minimum of 4 seconds the QD Pumptec or the Pumptec will shut off the motor.

The QD Pumptec is designed and calibrated expressly for use on Franklin Electric 230V 3-wire motors (1/3 to 1HP). The QD Pumptec must be installed in QD relay boxes.

The Pumptec is designed for use on Franklin Electric 2- and 3-wire motors (1/3 to 1 1/2 HP) 115 and 230V. The Pumptec is not designed for Jet Pumps.

**QD Pumptec & Pumptec -Trouble Shooting**

| Symptom | Checks or Solution |
|---|---|
| **QD Pumptec or Pumptec trips in about 4 seconds with some water delivery.** | A. Is the voltage more than 90% of nameplate rating?<br>B. Are the pump and motor correctly matched?<br>C. Is the **QD Pumptec** or **Pumptec** wired correctly?<br>For the **Pumptec** check the wiring diagram and pay special attention to the positioning of the power lead (230V or 115V).<br>For **QD Pumptec** is your system 230V 60 Hz or 220V 50 Hz? |
| **QD Pumptec or Pumptec trips in about 4 seconds with no water delivery.** | A. The pump may be airlocked. If there is a check valve on top of the pump, put another section of pipe between the pump and the check valve.<br>B. The pump may be out of water.<br>C. Check the valve settings. The pump may be dead-heading.<br>D. Pump or motor shaft may be broken.<br>E. Motor overload may be tripped. Check the motor current (amperage). |
| **QD Pumptec or Pumptec will not time out and reset.** | A. Check switch position on side of circuit board on **Pumptec.**<br>**QD Pumptec** check timer position on top/front of unit. Make sure the switch is not between settings.<br>B. If the reset time switch is set to manual reset (position 0), **QD Pumptec** and **Pumptec** will not reset (turn power off for 5 sec. then back on to reset). |
| **The pump/motor will not run at all.** | A. Check voltage.<br>B. Check wiring.<br>C. Remove the **QD Pumptec** from the control box. Reconnect wires in box to original state. If motor does not run the problem is not **QD Pumptec.**<br>Bypass **Pumptec** by connecting L2 and motor lead with jumper. Motor should run. If not, the problem is not **Pumptec**.<br>D. On **Pumptec** only, check that **Pumptec** is installed between the control switch and the motor. |
| **QD Pumptec or Pumptec will not trip when the pump breaks suction.** | A. Be sure you have a Franklin motor.<br>B. Check wiring connections. On **Pumptec** is lead power (230V or 115V) connected to correct terminal? Is motor lead connected to correct terminal?<br>C. Check for ground fault in the motor and excessive friction in the pump.<br>D. The well may be "gulping" enough water to keep **QD Pumptec** or **Pumptec** from tripping. It may be necessary to adjust the **QD Pumptec** or the **Pumptec** for these extreme applications. Call the Franklin Electric Service Hotline at 800-348-2420 for information.<br>E. On **Pumptec** applications does the control box have a run capacitor? If so, **Pumptec** will not trip. (Except for Franklin 1 1/2 HP motors) |
| **QD Pumptec or Pumptec chatters when running.** | A. Check for low voltage.<br>B. Check for waterlogged tank. Rapid cycling for any reason can cause the **QD Pumptec** or the **Pumptec** relay to chatter.<br>C. On **Pumptec** make sure the L2 and motor wires are installed correctly. If they are reversed, the unit can chatter. |

## Subtrol-Plus

### Subtrol-Plus - Trouble Shooting After Installation

| Symptom | Possible Cause or Solution |
|---|---|
| **Subtrol-Plus Dead** | When the Subtrol-Plus reset button is depressed and released, all indicator lights should flash. If line voltage is correct at the Subtrol-Plus and the L1, L2, L3 terminals, and the reset button does not cause lights to flash, Subtrol-Plus receiver is malfunctioning. |
| **Green Off Time Light Flashes** | The green light will flash and not allow operation unless both sensor coils are plugged into the receiver. If both are properly connected and it still flashes, the sensor coil or the receiver is faulty. An ohmmeter check between the two center terminals of each sensor coil connected should read less than 1 ohm, or coil is faulty. If both coils check good, receiver is faulty. |
| **Green Off Time Light On** | The green light is on and the Subtrol-Plus requires the specified off time before the pump can be restarted after having been turned off. If the green light is on except as described, the receiver is faulty. Note that a power interruption when the motor is running will initiate the delay function. |
| **Overheat Light On** | This is a normal protective function which turns off the pump when the motor reaches maximum safe temperatures. Check that amps are within the nameplate maximum on all three lines, and that the motor has proper water flow past it. If overheat trip occurs without apparent motor overheating, it may be the result of an arcing connection somewhere in the circuit or extreme noise interference on the power lines. Check with the power company or Franklin Electric. A true motor overheat trip will require at least five minutes for a motor started cold. If trips do not conform to this characteristic, suspect arcing connections, power line noise, ground fault, or SCR variable speed control equipment. |
| **Overload Light On** | This is a normal protective function, protecting against an overload or locked pump. Check the amps in all lines through a complete pumping cycle, and monitor whether low or unbalanced voltage may be causing high amps at particular times. If overload trip occurs without high amps, it may be caused by a faulty rating insert, receiver, or sensor coil. Recheck that the insert rating matches the motor. If it is correct, carefully remove it from the receiver by alternately lifting sides with a knife blade or thin screwdriver, and make sure it has no pins bent over. If the insert is correct and its pins are okay, replace receiver and/or sensor coils. |
| **Underload Light On** | This is a normal protective function.<br>A. Make sure the rating insert is the correct for the motor.<br>B. Adjusting the underload setting as described to allow the desired range of operating conditions. Note that a DECREASE in underload setting is required to allow loading without trip.<br>C. Check for drop in amps and delivery just before trip, indicating pump breaking suction, and for unbalanced line current.<br>D. With the power turned off, recheck motor lead resistance to ground. A grounded lead can cause underload trip. |

## Subtrol-Plus

### Subtrol-Plus - Trouble Shooting After Installation (Continued)

| Symptom | Possible Cause or Solution |
|---|---|
| **Tripped Light On** | Whenever the pump is off as a result of Subtrol-Plus protective function, the red tripped light is on. A steady light indicates the Subtrol-Plus will automatically allow the pump to restart as described, and a flashing light indicates repeated trips, requiring manual reset before the pump can be restarted. Any other red light operation indicates a faulty receiver. One-half voltage on 460V will cause tripped light on. |
| **Control Circuit Fuse Blows** | With power turned off, check for a shorted contactor coil or a grounded control circuit lead. The coil resistance should be at least 10 ohms and the circuit resistance to panel frame over 1 megohm. A standard or delay-type 2 amp fuse should be used. |
| **Contactor Will Not Close** | If proper voltage is at the control coil terminals when controls are operated to turn the pump on, but the contactor does not close, turn off power and replace the coil. If there is no voltage at the coil, trace the control circuit to determine if the fault is in the Subtrol-Plus receiver, fuse, wiring, or panel operating switches. This tracing can be done by first connecting a voltmeter at the coil terminals, and then moving the meter connections step by step along each circuit to the power source, to determine at which component the voltage is lost.<br><br>With the Subtrol-Plus receiver powered up, with all leads disconnected from the control terminals and with an ohmmeter set at R X 10, measure the resistance between the control terminals. It should measure 100 to 400 ohms. Depress and hold in the reset button. The resistance between the control terminals should measure close to infinity. |
| **Contactor Hums or Chatters** | Check that coil voltage is within 10% of rated voltage. If voltage is correct and matches line voltage, turn off power and remove the contactor magnetic assembly and check for wear, corrosion, and dirt. If voltage is erratic or lower than line voltage trace the control circuit for faults similar to the previous item, but looking for a major drop in voltage rather than its complete loss. |
| **Contactor Opens When Start Switch is Released** | Check that the small interlocks switch on the side of the contactor closes when the contactor closes. If the switch or circuit is open, the contactor will not stay closed when the selector switch is in HAND position. |
| **Contactor Closes But Motor Doesn't Run** | Turn off power. Check the contactor contacts for dirt, corrosion, and proper closing when the contactor is closed by hand. |
| **Signal Circuit Terminals Do Not Energize** | With the Subtrol-Plus receiver powered up and all leads disconnected from the Signal terminals, with an ohmmeter set at R X 10, measure the resistance between the Signal terminals. Resistance should measure close to infinite. Depress and hold in the reset button, the resistance between the signal terminals should measure 100 to 400 ohms. |

# Notes

# Notes

# Notes

## TOLL FREE HELP FROM A FRIEND

## 1-800-348-2420

### 1-219-827-5102 FAX

Phone Franklin's toll free SERVICE HOTLINE for answers to your installation questions on submersible pump motors. When you call, a Franklin expert will offer assistance in troubleshooting submersible systems and provide immediate answers to your motor application questions. Technical support is also available online. Visit our website at:

**www.franklin-electric.com**

Franklin Electric
Bluffton, Indiana 46714