FRANKLIN ELECTRIC

**2011 AIM MANUAL**

# Submersible Motors

Application ◆ Installation ◆ Maintenance

50 Hz, Single and Three-Phase Motors

**AUS-NZ**

System Solutions

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 WITHIN 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 1300 FRANKLIN 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.

# 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.

## ATTENTION

All installations and associated wiring is to be in accordance with AS/NZS 3000:2000 (Australian/New Zealand Wiring Rules).

Cable selection with respect to voltage drop and current carrying capacity is to be in accordance with AS/NZS 3008.1.1:1998 (Electrical Installations – Selection of Cables)

In Australia and New Zealand you may need to be licenced or hold a restricted licence to install, connect or disconnect an electrical appliance. Check with your state/regional electrical regulatory body first. Always use qualified tradespeople.

**The use of Non submersible electrical drop cable does not conform to the Wiring Rules AS/NZS 3008 as confirmed by all eight States/Territories and New Zealand Electrical Authorities as of May 2011**

Franklin Electric

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# 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°C; motors should be stored in areas that do not go below this temperature. The solution will partially freeze below -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 37°C, storage time should be limited to two years. Where temperatures reach 37° to 54°C, 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 13.57 N-m 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 13.57 N-m | Minimum Safe Torque-Load |
|---|---|---|---|
| HP | KW | | |
| 1 HP & Less | .75 KW & Less | 1 X 13.57 | 13.57 N-m |
| 20 HP | 15 KW | 20 X 13.57 | 271.4 N-m |
| 75 HP | 55 KW | 75 x 13.57 | 1017.8 N-m |
| 200 HP | 150 KW | 200 x 13.57 | 2714 N-m |

## Engine Driven Generators

Refer to generator manufacturers recommendations and locked rotor amps listed on page 13 (single-phase) and pages 16-17 (three-phase).

**Refer to Page 33**

## 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 7.5 metres 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 an 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 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 pump 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 the thrust shoes.

B. **Upthrust** - With no check valve, or with a leaking check valve, the unit start under a zero head condition. This causes an uplifting or upthrust on the impeller-shaft assembly in the pump. This 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 that 9.0 metres 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.

# Application - All Motors

## 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 are designed to operate up to full load horsepower in water up to 30°C. A flow of 7.62 cm/sec for 4" motors rated 2.2kW and higher, and 15.24 cm/sec for 6 and 8 inch motors is required for proper cooling. Table 6 shows minimum flow rates, in l/m, for various well diameters and motor sizes.

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

**TABLE 6 Required Cooling Flow**

| Minimum l/m required for motor cooling in water up to 30°C | | | |
|---|---|---|---|
| Casing or Sleeve I.D. (mm) | 4" Motor (2.2-7.5kW) 7.62 cm/sec. l/m | 6" Motor 15.24cm/sec l/m | 8" Motor 15.24cm/sec l/m |
| 102 | 4.5 | - | - |
| 127 | 26.5 | - | - |
| 152 | 49 | 34 | - |
| 178 | 76 | 95 | - |
| 203 | 114 | 170 | 40 |
| 254 | 189 | 340 | 210 |
| 305 | 303 | 530 | 420 |
| 356 | 416 | 760 | 645 |
| 406 | 568 | 1060 | 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 200 l/m will be installed in a 254 mm well. From Table 6, 340 l/m would be required to maintain proper cooling. In this case adding an 203 mm or smaller flow sleeve provides the required cooling.

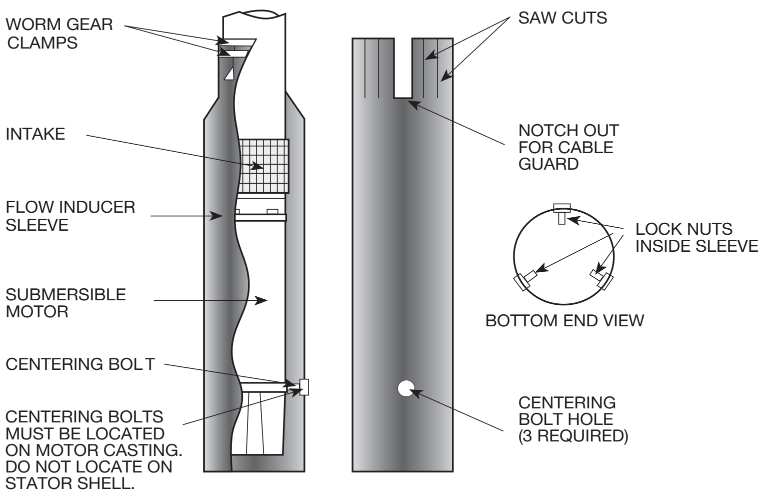



FIG. 1

## 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 Meters at Various Flow Rates**

| Motor Diameter | | 4" | 4" | 4" | 6" | 6" | 6" | 8" | 8" |
|---|---|---|---|---|---|---|---|---|---|
| Casing ID in mm | | 102 | 127 | 152 | 152 | 178 | 203 | 206 | 254 |
| Flow Rate in l/m | 95 | 0.09 | | | | | | | |
| | 189 | 0.37 | | | | | | | |
| | 378 | 1.4 | 0.09 | | 0.52 | | | | |
| | 568 | 3.1 | 0.18 | 0.06 | 1.1 | | | | |
| | 757 | | 0.34 | 0.12 | 1.9 | 0.15 | | 2.1 | |
| | 946 | | 0.55 | 0.21 | 2.9 | 0.24 | | 3.2 | |
| | 1136 | | 0.75 | 0.3 | 4.1 | 0.37 | 0.06 | 4.5 | |
| | 1514 | | | | 7.2 | 0.61 | 0.12 | 7.5 | |
| | 1893 | | | | | 0.94 | 0.21 | 11.4 | 0.2 |
| | 2271 | | | | | 1.3 | 0.3 | 15.9 | 0.3 |
| | 3028 | | | | | | | | 0.5 |
| | 3785 | | | | | | | | 0.7 |

## Hot Water Applications

When the pump-motor operates in water hotter than 30°C, a flow rate of at least .91 m/sec is required. When selecting the motor to drive a pump in over 30°C water, the motor horsepower must be de-rated per the following procedure.

1. Using Table 7A, determine pump l/m required for different well or sleeve diameters. If necessary, add a flow sleeve to obtain at least .91 m/sec flow rate.

**TABLE 7A Minimum l/m Required for .91 m/sec Flow Rate**

| Casing or Sleeve I.D. | 4" High Thrust Motor | 6" Motor | 8" Motor |
|---|---|---|---|
| mm | l/m | l/m | l/m |
| 102 | 57 | | |
| 127 | 303 | | |
| 152 | 606 | 197 | |
| 178 | | 568 | |
| 203 | | 984 | 227 |
| 254 | | 1970 | 1250 |
| 305 | | | 2460 |
| 356 | | | 3860 |
| 406 | | | 5530 |

2. Determine pump KW (HP) required from the pump manufacturer's curve.

3. Multiply the pump KW (HP) required by the heat factor multiplier from Table 8.

4. Select a rated KW (HP) motor that is at least the value calculated in Item 3.

**TABLE 8 Heat Factor Multiplier at .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 |
|---|---|---|---|
| 60°C | 1.25 | 1.62 | 2.00 |
| 55°C | 1.11 | 1.32 | 1.62 |
| 50°C | 1.00 | 1.14 | 1.32 |
| 45°C | 1.00 | 1.00 | 1.14 |
| 40°C | 1.00 | 1.00 | 1.00 |
| 35°C | 1.00 | 1.00 | 1.00 |

## Hot Water Applications - Example

EXAMPLE: A 6" pump end requiring 29.1 KW (39 HP) input will pump 51°C water in an 203 mm well at a delivery rate of 530 l/m. From Table 7A, a 152 mm flow sleeve will be required to increase the flow rate to at least .91 m/sec.

Using Table 8, the 1.62 heat factor multiplier is selected because the KW (HP) required is over 22 KW (30 HP) and water temperature is above 50°C. Multiply 29.1 KW x 1.62 (multiplier), which equals 47.1 KW (63.2 HP). This is the minimum rated full load horsepower usable at 21.9 KW (39 HP) in 51°C.

## 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

Electrical Codes require 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 Electrical Code, from the grounding terminal to the electrical supply ground.

Connect earth grounds to control boxes and panels per local and national codes or regulations.

**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 are designated IP 23. They are suitable for indoor and outdoor applications within temperatures of -10°C to 50°C. Operating control boxes below -10°C 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.

## Equipment Grounding

**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.**

The primary purpose of grounding the metal drop pipe and/or metal well casing in an installation is safety. It is done to limit the voltage between nonelectrical (exposed metal) parts of the system and ground, thus minimizing dangerous shock hazards. Using wire at least the size of the motor cable wires provides adequate current-carrying capability for any ground fault that might occur. It also provides a low resistance path to ground, ensuring that the current to ground will be large enough to trip any overcurrent device designed to detect faults (such as a ground fault circuit interrupter, or GFCI).

Normally, the ground wire to the motor would provide the primary path back to the power supply ground for any ground fault. There are conditions, however, where the ground wire connection could become compromised. One such example would be the case where the water in the well is abnormally corrosive or aggressive. In this example, a grounded metal drop pipe or casing would then become the primary path to ground. However, the many installations that now use plastic drop pipes and/or casings require further steps to be taken for safety purposes, so that the water column itself does not become the conductive path to ground.

When an installation has abnormally corrosive water AND the drop pipe or casing is plastic, Franklin Electric recommends the use of a GFCI with a 10 mA set-point. In this case, the motor ground wire should be routed through the current-sensing device along with the motor power leads. Wired this way, the GFCI will trip only when a ground fault has occurred AND the motor ground wire is no longer functional.

## 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, overload protectors, and, in some sizes, running capacitors.

### 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 KW 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.

### 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 waterlogged 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.

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

## 2- or 3-Wire Cable, 50 Hz (Service Entrance to Motor - Maximum Length In Metres)

Cable for submersible motors must be suitable for submerged operation, and adequate in size to operate within rated temperature and maintain adequate voltage at the motor. Cable may be twisted conductors with or without jacket, or flat molded type. Franklin 50HZ cable selections maintain motor voltage to at least 95% of supply voltage with maximum rated running amps, and maintain acceptable starting voltage and cable temperature.

**Minimum Square Millimetre cable for each rating is based on IEC Publication 364-5-523 (1983 Edition). Jacketed cable is based on Table 52-B1, Installation Method C In Table Using Column C in Table 52-C3 (70°C). Individual conductor is based on Table 52-B2, Installation Method G using Column 6 In Table 52-C10 (70°C).**

**Minimum AWG Cable sizes are based on the National Electrical Code in Table 430-150 for 75°C Cable In 30°C Maximum Ambient. Use Larger Cable if Local Codes Or Higher Temperatures Require It. Lengths in Bold Meet IEC and NEC Ampacity only For Individual Conductor Cables in air or water, not in conduit.**

Tables list the maximum recommended lengths in Meters for square millimeter copper cable sizes
The single-phase tables apply to all three wire types, and control boxes where required, may be at any point in the cable length. The portion of cable from service entrance to a three-phase controller should not exceed 25% of table maximum length to assure reliable starter operation.

**TABLE 11 Single-Phase Maximum Length of Copper Cable (metres)**

| Motor Rating | | | Metric Cable Size - 70° C Insulation - Copper Wire - Square Millimetres | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | KW | HP | 1.5 | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 50 | 70 | 95 |
| 220 Volt 50Hz. | .25 | 1/3 | 190 | 320 | 510 | 770 | 1260 | 1970 | 2960 | 3990 | 5340 | 6970 | 8750 |
| | .37 | 1/2 | 120 | 210 | 330 | 500 | 820 | 1290 | 1950 | 2640 | 3560 | 4680 | 5910 |
| | .55 | 3/4 | 80 | 140 | 230 | 350 | 580 | 900 | 1360 | 1830 | 2450 | 3210 | 4020 |
| | .75 | 1.0 | 60 | 110 | 180 | 270 | 440 | 690 | 1050 | 1430 | 1930 | 2550 | 3230 |
| | 1.1 | 1.5 | 40 | 70 | 120 | 190 | 310 | 490 | 750 | 1020 | 1390 | 1860 | 2380 |
| | 1.5 | 2.0 | 30 | 60 | 100 | 150 | 250 | 400 | 620 | 850 | 1180 | 1590 | 2070 |
| | 2.2 | 3.0 | **20** | 40 | 60 | 100 | 170 | 270 | 410 | 560 | 770 | 1030 | 1320 |
| | 3.7 | 5.0 | 0 | 0 | 40 | 60 | 110 | 170 | 260 | 370 | 520 | 710 | 930 |

1 Metre = 3.3 feet

## Two or More Different Cable Sizes Can Be Used

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

For example, in a replacement/upgrade installation, the well already has 40 Metres of buried 4mm$^2$ cable between the service entrance and the wellhead. A new 2.2kW, 230-volt, single-phase motor is being installed in a bore at 50 Metres to replace a smaller motor. The question is: Since there is already 40M of 4mm$^2$ installed, what size cable is required in the well with a 2.2kW, 230-volt, single-phase motor setting at 50 Metre?

From table 11, a 2.2kW motor can use up to 60 Metres of 4mm$^2$ cable. The application has 40 Metres of 4mm$^2$ copper wire installed.

Using the formula below, 40M (actual) ÷ 60M (max allowable) is equal to 0.666. This means 66.6% (0.666 x 100) of the allowable voltage drop occurs in this wire. This leaves us 33.4% (1.00 - 0.666 = 0.334) of some other wire size to use in the remaining 50 Metres "down hole" wire run.

**FIRST EXAMPLE**

The table shows 6mm$^2$ copper wire is good for 100 Metres. Using the formula again, 50M (used) ÷ 100M (allowed) = 0.5; adding this to the 0.666 determined earlier; 0.666 + 0.5 = 1.16. This combination is greater than 1.00, so the voltage drop will not meet the ASNZ3000 recommendations.

**SECOND EXAMPLE**

Tables 11 show 10mm$^2$ copper wire is good for 170 Metres. Using the formula, 50 ÷ 170 = 0.294, and using these numbers, 0.666 + 0.294 = 0.96, we find this is less than one and will meet the ASNZ3000 recommended voltage drop.

This works for two, three or more combinations of wire and it does not matter which size wire comes first in the installation.

**Formula:**

$$\frac{\text{Actual Length}}{\text{Max Allowed}} + \frac{\text{Actual Length}}{\text{Max Allowed}} = 1.00$$

**EXAMPLE:** 2.2kW, 230-Volt, Single-Phase Motor

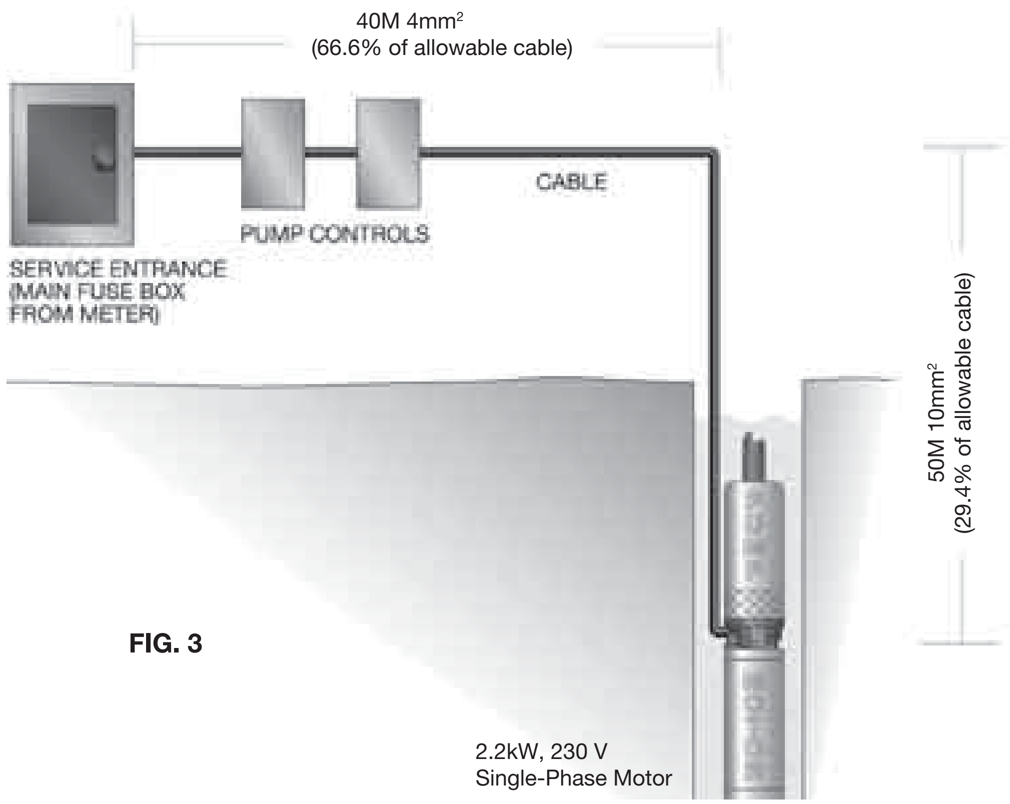



**FIG. 3**

# Application - Single-Phase Motors

**TABLE 13 - 18 Slot Single Phase Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor**

Applicable for Australia/New Zealand

| Type | Motor Model Prefix | Nameplate Rating | | | | | Full Load watts | Line to Line (1) Resistance (Ohms) | | Efficiency % | | | Power Factor % | | | Locked Rotor Amps | Circuit Breakers or Fuse Amps Typical Submersible | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kW | HP | Volts | Line Volts | Amps | | Main | Start | F.L. | 3/4 | 1/2 | F.L. | 3/4 | 1/2 | | Nontime Delay (Std) Fuse or Circuit Breaker | Dual Element Time Delay Fuse |
| 4 Inch 2-wire | 244 555 | 0.37 | 1/2 | 220 | 220 | 3.9 | 640 | 6.3-7.7 | | 59 | 55 | 48 | 74 | 65 | 54 | 26.3 | 15 | 5 |
| | | | | | 230 | 4.1 | 650 | | | 58 | 54 | 45 | 69 | 61 | 50 | | | |
| | | | | | 240 | 4.4 | 670 | | | 56 | 51 | 41 | 65 | 56 | 47 | | | |
| | 244 557 | 0.55 | 3/4 | 220 | 220 | 6 | 925 | 3.7-4.6 | | 61 | 57 | 49 | 71 | 61 | 50 | 36.1 | 20 | 7 |
| | | | | | 230 | 6.5 | 950 | | | 59 | 54 | 45 | 66 | 56 | 46 | | | |
| | | | | | 240 | 7.1 | 1000 | | | 56 | 50 | 40 | 61 | 52 | 43 | | | |
| | 244 558 | 0.75 | 1 | 220 | 220 | 7.3 | 1220 | 3.2-3.9 | | 61 | 59 | 53 | 77 | 67 | 55 | 44.9 | 20 | 9 |
| | | | | | 230 | 7.6 | 1230 | | | 61 | 57 | 49 | 72 | 62 | 51 | | | |
| | | | | | 240 | 7.9 | 1280 | | | 58 | 54 | 45 | 68 | 58 | 47 | | | |
| | 244 359 | 1.1 | 1 1/2 | 220 | 220 | 10.6 | 1730 | 2.2-2.7 | | 65 | 64 | 58 | 79 | 71 | 58 | 50.6 | 30 | 12 |
| | | | | | 230 | 10.8 | 1730 | | | 65 | 62 | 56 | 76 | 66 | 54 | | | |
| | | | | | 240 | 11 | 1780 | | | 63 | 60 | 52 | 71 | 62 | 49 | | | |
| 4 Inch 3-wire CS-IR (Cap Start) | 214 563 | 0.25 | 1/3 | 230 | 230 | 2.8 | 450 | 10.9-13.4 | 36.8-45.0 | 55 | 51 | 42 | 69 | 60 | 50 | 9.6 | 15 | 3.5 |
| | | | | | 240 | 3.0 | 465 | | | 53 | 48 | 39 | 65 | 56 | 47 | | | |
| | 214 565 | 0.37 | 1/2 | 230 | 230 | 4 | 655 | 7.6-9.3 | 19.9-24.4 | 57 | 54 | 47 | 73 | 64 | 52 | 13.2 | 15 | 4.5 |
| | | | | | 240 | 4.1 | 665 | | | 56 | 52 | 43 | 69 | 60 | 49 | | | |
| | 214 567 | 0.55 | 3/4 | 230 | 230 | 6 | 940 | 4.1-5.0 | 15.3-18.7 | 59 | 55 | 46 | 69 | 59 | 48 | 23 | 15 | 7 |
| | | | | | 240 | 6.5 | 980 | | | 57 | 51 | 42 | 63 | 54 | 45 | | | |
| | 214 568 | 0.75 | 1 | 230 | 230 | 7.3 | 1210 | 3.3-4.0 | 13.0-15.9 | 62 | 59 | 52 | 74 | 64 | 52 | 26.8 | 20 | 9 |
| | | | | | 240 | 7.6 | 1240 | | | 60 | 57 | 48 | 69 | 60 | 48 | | | |
| 4 Inch 3-wire CS-CR (Cap Start-Cap Run) | 224 560 | 1.1 | 1 1/2 | 230 | 230 | 8.9 | 1760 | 2.5-3.1 | 6.6-8.1 | 69 | 68 | 61 | 83 | 75 | 62 | 37.7 | 20 | 12 |
| | | | | | 240 | 9.1 | 1750 | | | 68 | 65 | 58 | 79 | 69 | 57 | | | |
| | 224 561 | 1.5 | 2 | 230 | 230 | 11.1 | 2210 | 2.1-2.6 | 7.4-9.0 | 70 | 69 | 62 | 88 | 81 | 68 | 51.5 | 30 | 15 |
| | | | | | 240 | 11.3 | 2260 | | | 69 | 66 | 58 | 84 | 75 | 62 | | | |
| | 224 562 | 2.2 | 3 | 230 | 230 | 15.9 | 3330 | 1.1-1.4 | 3.8-4.7 | 72 | 71 | 63 | 86 | 78 | 65 | 80.1 | 50 | 25 |
| | | | | | 240 | 16.6 | 3365 | | | 71 | 67 | 58 | 80 | 70 | 57 | | | |
| | 224 563 | 3.7 | 5 | 230 | 230 | 22.7 | 5040 | 1.0-1.2 | 2.8-3.5 | 75 | 74 | 67 | 98 | 96 | 91 | 119.2 | 70 | 30 |
| | | | | | 240 | 22.4 | 5080 | | | 75 | 72 | 64 | 96 | 92 | 83 | | | |
| 4 Inch 3-wire PSC (Permanent Split Capacitor) | 254 633 | 0.25 | 1/3 | 230 | 230 | 2.2 | 2860 | 11.0-12.2 | 25.7-28.4 | 53 | 45 | 34 | 95 | 92 | 85 | 7.7 | 15 | 4 |
| | | | | | 240 | 2.4 | 2862 | | | 50 | 42 | 30 | 90 | 86 | 77 | | | |
| | 254 634 | 0.37 | 1/2 | 230 | 230 | 3 | 650 | 7.1-8.7 | 15.8-19.3 | 58 | 51 | 40 | 95 | 91 | 85 | 11 | 15 | 4 |
| | | | | | 240 | 3.2 | 675 | | | 55 | 48 | 37 | 91 | 85 | 78 | | | |
| | 254 635 | 0.55 | 3/4 | 230 | 230 | 4.1 | 900 | 5.1-6.3 | 11.6-14.2 | 63 | 57 | 47 | 98 | 95 | 90 | 14.7 | 15 | 5 |
| | | | | | 240 | 4.1 | 910 | | | 62 | 55 | 45 | 95 | 91 | 83 | | | |
| | 254 636 | 0.75 | 1 | 230 | 230 | 5.4 | 1210 | 3.8-4.7 | 8.9-10.9 | 62 | 56 | 46 | 99 | 98 | 95 | 18.8 | 15 | 6 |
| | | | | | 240 | 5.4 | 1240 | | | 60 | 54 | 43 | 97 | 95 | 90 | | | |
| | 254 637 | 1.1 | 1 1/2 | 230 | 230 | 8 | 1760 | 2.6-3.2 | 5.7-7.0 | 64 | 58 | 48 | 98 | 95 | 89 | 27.8 | 25 | 12 |
| | | | | | 240 | 8.1 | 1800 | | | 62 | 56 | 45 | 95 | 89 | 81 | | | |
| | 254 638 | 1.5 | 2 | 230 | 230 | 10.3 | 2280 | 2.2-2.7 | 4.8-5.8 | 66 | 61 | 51 | 99 | 96 | 91 | 33.8 | 25 | 12 |
| | | | | | 240 | 10.2 | 2310 | | | 65 | 58 | 47 | 96 | 91 | 82 | | | |
| | 254 639 | 2.2 | 3 | 230 | 230 | 15.5 | 2815 | 1.4-1.5 | 3.1-3.4 | 65 | 59 | 50 | 99 | 98 | 95 | 53.2 | 50 | 25 |
| | | | | | 240 | 15.2 | 2840 | | | 64 | 58 | 48 | 97 | 95 | 89 | | | |

| | 3 Wire | | | PSC |
|---|---|---|---|---|
| | AUST | EUR | USA | EUR |
| Main / Run Winding | Blue | Blue/Grey | Black | Blue/Grey |
| Start / Aux Winding | White | Black | Red | Brown |
| Common | Red | Brown | Yellow | Black |

(1) Main/Run Winding Brown to Blue
Start/Aux Winding Brown to Black

**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.**

# Application - Single-Phase Motors

**TABLE 13 - 24 Slot Single Phase Motor (excludes 2-wire) Specifications (50 Hz), 2875 RPM, 1.0 Service Factor**

Applicable for Australia/New Zealand

| Type | Motor Model Prefix | Nameplate Rating | | | | | Full Load watts | Line to Line (1) Resistance (Ohms) | | Efficiency % | | | Power Factor % | | | Locked Rotor Amps | Circuit Breakers or Fuse Amps Typical Submersible | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kW | HP | Volts | Line Volts | Amps | | Main | Start | F.L. | 3/4 | 1/2 | F.L. | 3/4 | 1/2 | | Nontime Delay (Std) Fuse or Circuit Breaker | Dual Element Time Delay Fuse |
| 4 Inch 2-wire | 244 555 9*** | 0.37 | 1/2 | 220 | 220 | 3.9 | 640 | 6.3-7.7 | | 62 | 59 | 51 | 0.73 | 0.64 | 0.52 | 26.3 | 15 | 5 |
| | | | | | 230 | 4.1 | 650 | | | 61 | 57 | 49 | 0.69 | 0.63 | 0.51 | 27.5 | | |
| | 244 557 9*** | 0.55 | 3/4 | 220 | 220 | 6 | 925 | 3.7-4.6 | | 63 | 59 | 52 | 0.69 | 0.59 | 0.48 | 36.1 | 20 | 7 |
| | | | | | 230 | 6.5 | 950 | | | 61 | 56 | 49 | 0.65 | 0.57 | 0.46 | 37.7 | | |
| | 244 558 9*** | 0.75 | 1 | 220 | 220 | 7.3 | 1220 | 3.2-3.9 | | 64 | 62 | 56 | 0.75 | 0.66 | 0.54 | 44.9 | 20 | 9 |
| | | | | | 230 | 7.6 | 1230 | | | 63 | 60 | 54 | 0.71 | 0.64 | 0.52 | 46.9 | | |
| | 244 359 9*** | 1.1 | 1 1/2 | 220 | 220 | 10.6 | 1730 | 2.2-2.7 | | 64 | 61 | 55 | 0.78 | 0.69 | 0.58 | 50.6 | 30 | 12 |
| | | | | | 230 | 10.8 | 1730 | | | 63 | 60 | 53 | 0.76 | 0.65 | 0.55 | 58.5 | | |
| 4 Inch 3-wire CS-IR (Cap Start) | 214 753 1*** | 0.25 | 1/3 | 230 | 220 | 2.8 | 475 | 10.6-13.0 | 38.3 - 46.8 | 53 | 50 | 43 | 0.78 | 0.70 | 0.61 | 9.6 | 15 | 3.5 |
| | | | | | 230 | 2.7 | 475 | | | 53 | 50 | 42 | 0.75 | 0.67 | 0.58 | | | |
| | 214 755 1*** | 0.37 | 1/2 | 230 | 220 | 3.9 | 660 | 7.3 - 8.9 | 23.9 - 29.3 | 56 | 55 | 48 | 0.77 | 0.69 | 0.58 | 13.2 | 15 | 4.5 |
| | | | | | 230 | 4 | 660 | | | 56 | 53 | 46 | 0.74 | 0.65 | 0.55 | | | |
| | 214 757 1*** | 0.55 | 3/4 | 230 | 220 | 5.9 | 980 | 4.8 - 5.8 | 18.5 - 22.7 | 56 | 53 | 46 | 0.77 | 0.69 | 0.58 | 21.6 | 15 | 7 |
| | | | | | 230 | 5.9 | 975 | | | 56 | 53 | 45 | 0.73 | 0.64 | 0.53 | | | |
| | 214 758 1*** | 0.75 | 1 | 230 | 220 | 7.3 | 1250 | 3.5 - 4.3 | 14.8 - 18.0 | 60 | 59 | 53 | 0.79 | 0.71 | 0.59 | 26.6 | 20 | 9 |
| | | | | | 230 | 7.3 | 1240 | | | 61 | 58 | 51 | 0.76 | 0.67 | 0.55 | | | |
| 4 Inch 3-wire CS-CR (Cap Start-Cap Run) | 224 750 1*** | 1.1 | 1 1/2 | 230 | 220 | 8.6 | 1590 | 2.6 - 3.2 | 7.0 - 8.5 | 69 | 68 | 63 | 0.87 | 0.80 | 0.69 | 41.3 | 20 | 12 |
| | | | | | 230 | 8.6 | 1615 | | | 68 | 67 | 60 | 0.84 | 0.76 | 0.65 | | | |
| | 224 751 1*** | 1.5 | 2 | 230 | 220 | 10.6 | 2125 | 2.0 - 2.4 | 5.3 - 6.4 | 71 | 71 | 66 | 0.91 | 0.85 | 0.75 | 55.4 | 30 | 15 |
| | | | | | 230 | 10.4 | 2120 | | | 71 | 70 | 64 | 0.88 | 0.81 | 0.69 | | | |
| | 224 752 2*** | 2.2 | 3 | 230 | 220 | 15.9 | 2990 | 1.3 - 1.6 | 3.8 - 4.6 | 74 | 73 | 67 | 0.76 | 0.86 | 0.91 | 74.5 | 50 | 25 |
| | | | | | 230 | 16.6 | 3025 | | | 73 | 70 | 63 | 0.69 | 0.80 | 0.88 | | | |
| | 224 752 3*** | 2.2 | 3 | 230 | 220 | 15.9 | 2990 | 1.3 - 1.6 | 3.8 - 4.6 | 74 | 73 | 67 | 0.76 | 0.86 | 0.91 | 74.5 | 50 | 25 |
| | | | | | 230 | 16.6 | 3025 | | | 73 | 70 | 63 | 0.69 | 0.80 | 0.88 | | | |
| 4 Inch 3-wire PSC (Permanent Split Capacitor) | 224 753 3*** | 3.7 | 5 | 230 | 220 | 22.7 | 4770 | 1.0 - 1.3 | 2.4 - 2.9 | 78 | 77 | 72 | 0.98 | 0.99 | 0.99 | 101 | 70 | 30 |
| | | | | | 230 | 22.4 | 4775 | | | 77 | 76 | 70 | 0.96 | 0.98 | 0.99 | | | |
| | 254 815 1*** | 0.37 | 1/2 | 230 | 230 | 3.1 | 685 | 7.1 - 8.6 | 20.8 - 25.4 | 54 | 47 | 36 | 0.97 | 0.92 | 0.86 | 12.1 | 15 | 4 |
| | | | | | 240 | 3.2 | 685 | | | 54 | 46 | 35 | 0.91 | 0.85 | 0.78 | | | |
| | 254 817 1*** | 0.55 | 3/4 | 230 | 230 | 4.0 | 875 | 4.4 - 5.4 | 13.1 - 16.0 | 63 | 57 | 46 | 0.98 | 0.97 | 0.94 | 16.9 | 15 | 5 |
| | | | | | 240 | 4.1 | 875 | | | 63 | 57 | 45 | 0.64 | 0.91 | 0.86 | | | |
| | 254 818 1*** | 0.75 | 1 | 230 | 230 | 5.5 | 1230 | 4.2 - 5.2 | 8.5 - 10.4 | 61 | 54 | 44 | 0.99 | 0.99 | 0.97 | 21.8 | 15 | 6 |
| | | | | | 240 | 5.5 | 1270 | | | 59 | 52 | 41 | 0.98 | 0.96 | 0.92 | | | |
| | 254 819 1*** | 1.1 | 1 1/2 | 230 | 230 | 7.8 | 1695 | 2.5 - 3.0 | 6.7 - 8.2 | 65 | 59 | 47 | 0.97 | 0.94 | 0.86 | 32.5 | 25 | 6 |
| | | | | | 240 | 8.1 | 1745 | | | 63 | 56 | 43 | 0.92 | 0.86 | 0.77 | | | |
| | 254 820 1*** | 1.5 | 2 | 230 | 230 | 10.0 | 2205 | 1.9 - 2.3 | 4.4 - 5.3 | 68 | 63 | 52 | 0.98 | 0.95 | 0.90 | 40 | 25 | 12 |
| | | | | | 240 | 10.2 | 2275 | | | 66 | 59 | 48 | 0.95 | 0.90 | 0.82 | | | |
| | 254 821 2*** | 2.2 | 3 | 230 | 230 | 14.0 | 3145 | 1.3 -1.6 | 3.0 - 3.6 | 70 | 65 | 55 | 0.99 | 0.98 | 0.93 | 59.3 | 25 | 12 |
| | | | | | 240 | 14.1 | 3235 | | | 68 | 62 | 51 | 0.97 | 0.93 | 0.86 | | | |

| | 3 Wire | | |
|---|---|---|---|
| | AUST | EUR | USA |
| Main / Run Winding | Blue | Blue/Grey | Black |
| Start / Aux Winding | White | Black | Red |
| Common | Red | Brown | Yellow |

(1) Main/Run Winding Brown to Blue
Start/Aux Winding Brown to Black

**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.**

## TABLE 14 Three and Six Wire Cable, 50 Hz Service Entrance to Motor - Maximum Length in Meters 70°C

| Motor Rating | | | Metric Cable Size, Square Millimeters, Copper Wire - 70°C Rated Insulation | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | KW | HP | 1.5 | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 50 | 70 | 95 | 120 | 150 | 185 | 240 | 300 | 400 |
| 220v 50Hz 3Ø 3 - Lead (230V may use 110% of table) (240V may use 119% of table) | .37 | 1/2 | 300 | 510 | 820 | 1230 | 2010 | 3160 | 4810 | 6540 | 8890 | | | | | | | | |
| | .55 | 3/4 | 200 | 350 | 550 | 830 | 1370 | 2150 | 3280 | 4460 | 6060 | 8060 | | | | | | | |
| | .75 | 1 | 160 | 270 | 430 | 650 | 1070 | 1680 | 2550 | 3470 | 4710 | 6250 | 7970 | 9510 | | | | | |
| | 1.1 | 1 1/2 | 110 | 190 | 300 | 450 | 750 | 1170 | 1790 | 2430 | 3310 | 4400 | 5620 | 6700 | 7790 | 8970 | | | |
| | 1.5 | 2 | 80 | 140 | 230 | 340 | 570 | 900 | 1380 | 1880 | 2570 | 3430 | 4410 | 5290 | 6180 | 7150 | 8470 | 9670 | |
| | 2.2 | 3 | 50 | 90 | 150 | 230 | 380 | 600 | 920 | 1270 | 1740 | 2330 | 3000 | 3610 | 4230 | 4910 | 5840 | 6700 | 7790 |
| | 3 | 4 | 40 | 70 | 110 | 170 | 280 | 440 | 670 | 920 | 1270 | 1700 | 2180 | 2630 | 3080 | 3570 | 4240 | 4850 | 5630 |
| | 3.7 | 5 | 30 | 50 | 90 | 130 | 220 | 360 | 550 | 750 | 1030 | 1390 | 1790 | 2150 | 2520 | 2930 | 3480 | 4000 | 4640 |
| | 4 | 5 1/2 | 30 | 50 | 80 | 120 | 200 | 320 | 490 | 670 | 920 | 1240 | 1590 | 1910 | 2240 | 2590 | 3070 | 3520 | 4070 |
| | 5.5 | 7 1/2 | 0 | 30 | 60 | 90 | 150 | 240 | 380 | 520 | 710 | 960 | 1240 | 1490 | 1750 | 2040 | 2430 | 2790 | 3250 |
| | 7.5 | 10 | 0 | 0 | 40 | 60 | 110 | 170 | 270 | 370 | 500 | 680 | 870 | 1050 | 1230 | 1420 | 1690 | 1930 | 2230 |
| | 11 | 15 | 0 | 0 | 0 | **40** | 80 | 120 | 190 | 270 | 370 | 500 | 650 | 790 | 930 | 1080 | 1290 | 1490 | 1740 |
| | 15 | 20 | 0 | 0 | 0 | 0 | 60 | 90 | 150 | 200 | 280 | 380 | 500 | 610 | 720 | 840 | 1010 | 1170 | 1370 |
| | 18.5 | 25 | 0 | 0 | 0 | 0 | 0 | 70 | 110 | 160 | 220 | 300 | 390 | 480 | 570 | 660 | 800 | 920 | 1090 |
| | 22 | 30 | 0 | 0 | 0 | 0 | 0 | **60** | 100 | 130 | 190 | 260 | 330 | 400 | 480 | 560 | 670 | 780 | 910 |
| 380v 50Hz 3Ø 3 - Lead (400V may use 110% of table) (415V may use 119% of table) | .37 | 1/2 | 930 | 1550 | 2460 | 3670 | 6030 | 9460 | | | | | | | | | | | |
| | .55 | 3/4 | 630 | 1050 | 1670 | 2500 | 4100 | 6440 | 9790 | | | | | | | | | | |
| | .75 | 1 | 490 | 820 | 1300 | 1950 | 3200 | 5020 | 7620 | | | | | | | | | | |
| | 1.1 | 1 1/2 | 340 | 570 | 910 | 1360 | 2240 | 3520 | 5350 | 7280 | 9890 | | | | | | | | |
| | 1.5 | 2 | 260 | 430 | 700 | 1040 | 1720 | 2700 | 4120 | 5630 | 7690 | | | | | | | | |
| | 2.2 | 3 | 170 | 290 | 460 | 700 | 1150 | 1810 | 2770 | 3790 | 5190 | 6950 | 8950 | | | | | | |
| | 3 | 4 | 120 | 210 | 340 | 510 | 840 | 1330 | 2030 | 2770 | 3790 | 5070 | 6530 | 7840 | 9190 | | | | |
| | 3.7 | 5 | 100 | 170 | 270 | 410 | 680 | 1080 | 1650 | 2260 | 3090 | 4140 | 5340 | 6420 | 7540 | 8750 | | | |
| | 4 | 5 1/2 | 90 | 150 | 250 | 370 | 610 | 970 | 1480 | 2020 | 2770 | 3700 | 4750 | 5710 | 6680 | 7740 | 9180 | | |
| | 5.5 | 7 1/2 | 70 | 110 | 190 | 280 | 470 | 740 | 1140 | 1560 | 2140 | 2870 | 3700 | 4460 | 5240 | 6090 | 7250 | 8330 | 9700 |
| | 7.5 | 10 | **50** | 80 | 130 | 200 | 330 | 530 | 810 | 1110 | 1510 | 2030 | 2610 | 3130 | 3670 | 4250 | 5040 | 5770 | 6680 |
| | 11 | 15 | 0 | 60 | 90 | 140 | 240 | 380 | 590 | 810 | 1120 | 1510 | 1950 | 2350 | 2770 | 3230 | 3860 | 4450 | 5200 |
| | 15 | 20 | 0 | 0 | 70 | 110 | 180 | 290 | 450 | 620 | 860 | 1160 | 1500 | 1820 | 2150 | 2520 | 3020 | 3490 | 4110 |
| | 18.5 | 25 | 0 | 0 | 0 | 80 | 140 | 230 | 350 | 490 | 680 | 910 | 1190 | 1440 | 1700 | 1990 | 2390 | 2770 | 3260 |
| | 22 | 30 | 0 | 0 | 0 | 0 | 120 | 190 | 300 | 410 | 570 | 770 | 1000 | 1210 | 1440 | 1680 | 2010 | 2330 | 2740 |
| | 30 | 40 | 0 | 0 | 0 | 0 | 0 | 140 | 220 | 310 | 420 | 570 | 740 | 900 | 1060 | 1230 | 1470 | 1700 | 1990 |
| | 37 | 50 | 0 | 0 | 0 | 0 | 0 | **110** | 180 | 240 | 340 | 460 | 590 | 710 | 840 | 980 | 1170 | 1350 | 1580 |
| | 45 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 150 | 200 | 280 | 380 | 490 | 600 | 700 | 820 | 980 | 1130 | 1330 |
| | 55 | 75 | 0 | 0 | 0 | 0 | 0 | 0 | **120** | 170 | 240 | 330 | 420 | 510 | 610 | 710 | 860 | 990 | 1170 |
| | 75 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **180** | 240 | 320 | 390 | 460 | 530 | 640 | 740 | 880 |
| | 90 | 125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **190** | 240 | 290 | 350 | 400 | 480 | 550 | 650 |
| | 110 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 210 | 250 | 290 | 340 | 410 | 470 | 550 |
| | 130 | 175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **180** | 220 | 260 | 300 | 360 | 420 | 500 |
| | 150 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **190** | 230 | 270 | 320 | 370 | 440 |

### 6 - Lead Wye - Delta

| Motor Rating | | | Metric Cable Size, Square Millimeters, Copper Wire - 70°C Rated Insulation | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | KW | HP | 1.5 | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 50 | 70 | 95 | 120 | 150 | 185 | 240 | 300 | 400 |
| 220v 50Hz 3Ø 6 - Lead (230V = 110%) (240V = 119%) | 3.7 | 5 | 40 | 70 | 130 | 190 | 330 | 540 | 820 | 1120 | 1540 | 2080 | 2680 | 3220 | 3780 | 4390 | 5220 | 6000 | 6960 |
| | 5.5 | 7 1/2 | 30 | 40 | 90 | 130 | 220 | 360 | 570 | 780 | 1060 | 1440 | 1860 | 2230 | 2620 | 3060 | 3640 | 4180 | 4870 |
| | 7.5 | 10 | **10** | 30 | 60 | 90 | 160 | 250 | 400 | 550 | 750 | 1020 | 1300 | 1570 | 1840 | 2130 | 2530 | 2890 | 3340 |
| | 11 | 15 | 0 | 30 | 40 | 60 | 120 | 180 | 280 | 400 | 550 | 750 | 970 | 1180 | 1390 | 1620 | 1930 | 2230 | 2610 |
| | 15 | 20 | 0 | 0 | 30 | 40 | 90 | 130 | 220 | 300 | 420 | 570 | 750 | 910 | 1080 | 1260 | 1510 | 1750 | 2050 |
| | 18.5 | 25 | 0 | 0 | 0 | 30 | 60 | 100 | 160 | 240 | 330 | 450 | 580 | 720 | 850 | 990 | 1200 | 1380 | 1630 |
| | 22 | 30 | 0 | 0 | 0 | 0 | 60 | 90 | 150 | 190 | 280 | 390 | 490 | 600 | 720 | 840 | 1000 | 1170 | 1360 |
| 380v 50Hz 3Ø 6 - Lead (400V may use 110% of table) (415V may use 119% of table) | 3.7 | 5 | 150 | 250 | 400 | 610 | 1020 | 1620 | 2470 | 3390 | 4630 | 6210 | 8010 | 9630 | | | | | |
| | 5.5 | 7 1/2 | 100 | 160 | 280 | 420 | 700 | 1110 | 1710 | 2340 | 3210 | 4300 | 5550 | 6690 | 7860 | 9130 | | | |
| | 7.5 | 10 | 70 | 120 | 190 | 300 | 490 | 790 | 1210 | 1660 | 2260 | 3040 | 3910 | 4690 | 5500 | 6370 | 7560 | 8650 | |
| | 11 | 15 | 40 | 90 | 130 | 210 | 360 | 570 | 880 | 1210 | 1680 | 2260 | 2920 | 3520 | 4150 | 4840 | 5790 | 6670 | 7800 |
| | 15 | 20 | **30** | 60 | 100 | 160 | 270 | 430 | 670 | 930 | 1290 | 1740 | 2250 | 2730 | 3220 | 3780 | 4530 | 5230 | 6160 |
| | 18.5 | 25 | 0 | 40 | 70 | 120 | 210 | 340 | 520 | 730 | 1020 | 1360 | 1780 | 2160 | 2550 | 2980 | 3580 | 4150 | 4890 |
| | 22 | 30 | 0 | 0 | 70 | 100 | 180 | 280 | 450 | 610 | 850 | 1150 | 1500 | 1810 | 2160 | 2520 | 3010 | 3490 | 4110 |
| | 30 | 40 | 0 | 0 | 0 | 70 | 130 | 210 | 330 | 460 | 630 | 850 | 1110 | 1350 | 1590 | 1840 | 2200 | 2550 | 2980 |
| | 37 | 50 | 0 | 0 | 0 | 0 | 100 | 160 | 270 | 360 | 510 | 690 | 880 | 1060 | 1260 | 1470 | 1750 | 2020 | 2370 |
| | 45 | 60 | 0 | 0 | 0 | 0 | 90 | 130 | 220 | 300 | 420 | 570 | 730 | 900 | 1050 | 1230 | 1470 | 1690 | 1990 |
| | 55 | 75 | 0 | 0 | 0 | 0 | 0 | 120 | 180 | 250 | 360 | 490 | 630 | 760 | 910 | 1060 | 1290 | 1480 | 1750 |
| | 75 | 100 | 0 | 0 | 0 | 0 | 0 | **90** | 130 | 190 | 270 | 360 | 480 | 580 | 690 | 790 | 960 | 1110 | 1320 |
| | 90 | 125 | 0 | 0 | 0 | 0 | 0 | 0 | **100** | 150 | 210 | 280 | 360 | 430 | 520 | 600 | 720 | 820 | 970 |
| | 110 | 150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **120** | 180 | 240 | 310 | 370 | 430 | 510 | 610 | 700 | 820 |
| | 130 | 175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **150** | 210 | 270 | 330 | 390 | 450 | 540 | 630 | 750 |
| | 150 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **130** | 180 | 240 | 280 | 340 | 400 | 480 | 550 | 660 |

1 Meter = 3.3 feet

Lengths in **BOLD** meet the IEC ampacity only for individual conductor cable in free air or water, not in conduit.

Ampacities are determined from IEC publication 364-5-523 (1983 edition).

Jacketed cable is based on Table 52-B1, Installation method C using Column C in Table 52-C3 (70°C).

Individual Conductor is based on Table 52-B2, Installation method G using Column 6 in Table 52-C10 (70°C).

## TABLE 15 Three and Six Wire Cable, 50 Hz Service Entrance to Motor – Maximum Length in Metres

**90°C**

| Motor Rating | | | Metric Cable Size, Square Millimeters, Copper Wire - 90°C Rated Insulation | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | kW | HP | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 50 | 70 | 95 | 120 | 150 | 185 | 240 | 300 | 400 |
| 415v 50Hz 3Ø 3-Lead | 4 | 5.5 | 190 | 300 | 460 | 750 | | | | | | | | | | | | |
| | 5.5 | 7.5 | 140 | 220 | 340 | 560 | 880 | | | | | | | | | | | |
| | 7.5 | 10 | 100 | 160 | 250 | 410 | 650 | 990 | | | | | | | | | | |
| | 9.3 | 12.5 | 80 | 140 | 210 | 340 | 540 | 830 | | | | | | | | | | |
| | 11 | 15 | 70 | 110 | 170 | 290 | 460 | 700 | 950 | | | | | | | | | |
| | 13 | 17.5 | 60 | 100 | 150 | 250 | 390 | 600 | 810 | | | | | | | | | |
| | 15 | 20 | **50** | 80 | 130 | 220 | 340 | 520 | 710 | 970 | | | | | | | | |
| | 18.5 | 25 | **40** | 70 | 100 | 170 | 270 | 420 | 570 | 780 | 1020 | | | | | | | |
| | 22 | 30 | | **60** | 90 | 150 | 230 | 360 | 490 | 660 | 880 | | | | | | | |
| | 26 | 35 | | **50** | **70** | 120 | 200 | 300 | 410 | 560 | 750 | 950 | | | | | | |
| | 30 | 40 | | | **60** | 110 | 170 | 260 | 360 | 490 | 640 | 820 | 970 | | | | | |
| | 37 | 50 | | | | **80** | 140 | 210 | 290 | 390 | 520 | 660 | 780 | 900 | | | | |
| | 45 | 60 | | | | **70** | 120 | 180 | 250 | 350 | 470 | 600 | 720 | 850 | 980 | | | |
| | 52 | 70 | | | | | **100** | 160 | 220 | 310 | 410 | 530 | 640 | 750 | 860 | 1020 | | |
| | 55 | 75 | | | | | **100** | 150 | 210 | 290 | 380 | 490 | 590 | 690 | 800 | 940 | | |
| | 60 | 80 | | | | | **90** | 140 | 190 | 270 | 360 | 460 | 560 | 660 | 760 | 900 | | |
| | 67 | 90 | | | | | **80** | **120** | 170 | 240 | 320 | 410 | 490 | 570 | 660 | 780 | 890 | |
| | 75 | 100 | | | | | | **110** | 150 | 210 | 280 | 360 | 440 | 510 | 590 | 700 | 800 | 920 |
| | 83 | 111 | | | | | | **100** | **140** | 200 | 260 | 340 | 410 | 480 | 560 | 660 | 760 | 880 |
| | 85 | 114 | | | | | | **90** | **130** | 190 | 240 | 310 | 370 | 440 | 510 | 600 | 680 | 780 |
| | 93 | 125 | | | | | | | **120** | **170** | 230 | 290 | 350 | 410 | 470 | 550 | 630 | 730 |
| | 110 | 150 | | | | | | | **100** | **130** | 180 | 230 | 280 | 320 | 370 | 430 | 490 | 550 |
| | 130 | 175 | | | | | | | | **120** | **160** | 210 | 250 | 290 | 340 | 400 | 450 | 520 |
| | 150 | 200 | | | | | | | | | **140** | **180** | 210 | 250 | 290 | 340 | 390 | 450 |
| | 185 | 250 | | | | | | | | | | **140** | **160** | **190** | 220 | 260 | 290 | 330 |

## 6 - Lead Star (Wye) - Delta

**90°C**

| Motor Rating | | | Metric Cable Size, Square Millimeters, Copper Wire - 90°C Rated Insulation | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volts | kW | HP | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 50 | 70 | 95 | 120 | 150 | 185 | 240 | 300 | 400 |
| 415v 50Hz 3Ø 6-Lead | 4 | 5.5 | 280 | 450 | 690 | | | | | | | | | | | | | |
| | 5.5 | 7.5 | 210 | 330 | 510 | 840 | | | | | | | | | | | | |
| | 7.5 | 10 | 150 | 240 | 370 | 610 | 970 | | | | | | | | | | | |
| | 9.3 | 12.5 | 120 | 210 | 310 | 510 | 810 | | | | | | | | | | | |
| | 11 | 15 | 100 | 160 | 250 | 430 | 690 | | | | | | | | | | | |
| | 13 | 17.5 | 90 | 150 | 220 | 370 | 580 | 900 | | | | | | | | | | |
| | 15 | 20 | 70 | 120 | 190 | 330 | 510 | 780 | | | | | | | | | | |
| | 18.5 | 25 | 60 | 100 | 150 | 250 | 400 | 630 | 850 | | | | | | | | | |
| | 22 | 30 | 40 | 90 | 130 | 220 | 340 | 540 | 730 | 990 | | | | | | | | |
| | 26 | 35 | **40** | 70 | 100 | 180 | 300 | 450 | 610 | 840 | | | | | | | | |
| | 30 | 40 | **30** | 60 | 90 | 160 | 250 | 390 | 540 | 730 | 960 | | | | | | | |
| | 37 | 50 | | **40** | 70 | 120 | 210 | 310 | 430 | 580 | 780 | 990 | | | | | | |
| | 45 | 60 | | **40** | **60** | 100 | 180 | 270 | 370 | 520 | 700 | 900 | | | | | | |
| | 52 | 70 | | | **60** | 90 | 150 | 240 | 330 | 460 | 610 | 790 | 960 | | | | | |
| | 55 | 75 | | | **40** | 90 | 150 | 220 | 310 | 430 | 570 | 730 | 880 | | | | | |
| | 60 | 80 | | | **40** | 70 | 130 | 210 | 280 | 400 | 540 | 690 | 840 | 990 | | | | |
| | 67 | 90 | | | | **70** | 120 | 180 | 250 | 360 | 480 | 610 | 730 | 850 | 990 | | | |
| | 75 | 100 | | | | **60** | 100 | 160 | 220 | 310 | 420 | 540 | 660 | 760 | 880 | | | |
| | 83 | 111 | | | | **60** | 90 | 150 | 210 | 300 | 390 | 510 | 610 | 720 | 840 | 990 | | |
| | 85 | 114 | | | | **60** | **90** | 130 | 190 | 270 | 360 | 460 | 550 | 660 | 760 | 900 | 1020 | |
| | 93 | 125 | | | | | **70** | 130 | 180 | 250 | 340 | 430 | 520 | 610 | 700 | 820 | 940 | |
| | 110 | 150 | | | | | **60** | **100** | 150 | 190 | 270 | 340 | 420 | 480 | 550 | 640 | 730 | 820 |
| | 130 | 175 | | | | | | **90** | **130** | 180 | 240 | 310 | 370 | 430 | 510 | 600 | 670 | 780 |
| | 150 | 200 | | | | | | **70** | **100** | 150 | 210 | 270 | 310 | 370 | 430 | 510 | 580 | 670 |
| | 185 | 250 | | | | | | | **90** | **120** | 160 | 210 | 240 | 280 | 330 | 390 | 430 | 490 |

Lengths in meters for noted voltage drop from motor to service entrance.
Lengths in **BOLD** meet the IEC ampacity only for individual conductor cable in free air or water, not in conduit.
Ampacities determined from IEC Publication 364-5-523 (1983 edition).
Jacketed cable based on Table 52-B1, Installation Method C using Column C in Tables 52-C3 (70°C and 52-C4 (90°C).
Individual conductors based on Table 52-B2, Installation Method G using Column 6 in Tables 52-C10 (70°C and 52-C11 (90°C).

**TABLE 16 - 18 Slot Three Phase Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor**

Applicable for Australia/New Zealand

| Type | Motor Model Prefix | Nameplate Rating | | | | | Full Load watts | Line to Line Resistance (Ohms) | Efficiency % | | | Power Factor % | | | Locked Rotor Amps | Circuit Breakers or Fuse Amps - Typical Submersible | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kW | HP | Volts | Line Volts | Amps | | | F.L. | 3/4 | 1/2 | F.L. | 3/4 | 1/2 | | Nontime Delay (Std) Fuse or Circuit Breaker | Dual Element Time Delay Fuse |
| 4 Inch | 234 561 | 0.37 | 1/2 | 380-415 | 380 | 1.1 | 550 | 25.9 - 31.7 | 70 | 68 | 63 | 79 | 70 | 57 | 8.9 | 15 | 4 |
| | | | | | 400 | 1.1 | | | 69 | 67 | 60 | 75 | 65 | 52 | 9.3 | | |
| | | | | | 415 | 1.2 | | | 68 | 65 | 57 | 71 | 61 | 49 | 9.8 | | |
| | 234 562 | 0.55 | 3/4 | 380-415 | 380 | 1.6 | 810 | 13.4 - 16.3 | 72 | 72 | 69 | 81 | 73 | 59 | 13.8 | 15 | 3 |
| | | | | | 400 | 1.6 | | | 73 | 71 | 66 | 76 | 67 | 53 | 14.5 | | |
| | | | | | 415 | 1.7 | | | 72 | 70 | 64 | 72 | 62 | 49 | 15.3 | | |
| | 234 563 | 0.75 | 1 | 380-415 | 380 | 2.1 | 1050 | 9.1 - 11.1 | 73 | 72 | 69 | 81 | 72 | 59 | 18.6 | 15 | 4.5 |
| | | | | | 400 | 2.1 | | | 73 | 71 | 66 | 76 | 66 | 53 | 19.2 | | |
| | | | | | 415 | 2.2 | | | 72 | 69 | 63 | 72 | 61 | 48 | 20.2 | | |
| | 234 524 | 1.1 | 1 1/2 | 380-415 | 380 | 3 | 1470 | 7.2 - 8.8 | 75 | 75 | 72 | 81 | 72 | 58 | 28.7 | 15 | 7 |
| | | | | | 400 | 3 | | | 75 | 73 | 69 | 75 | 64 | 51 | 28.9 | | |
| | | | | | 415 | 3.1 | | | 73 | 71 | 66 | 69 | 59 | 45 | 30.8 | | |
| | 234 525 | 1.5 | 2 | 380-415 | 380 | 3.9 | 2120 | 4.5 - 5.5 | 76 | 76 | 73 | 81 | 72 | 58 | 39.9 | 20 | 9 |
| | | | | | 400 | 4 | | | 76 | 74 | 70 | 75 | 65 | 51 | 41.6 | | |
| | | | | | 415 | 4.1 | | | 75 | 73 | 67 | 70 | 59 | 46 | 43.3 | | |
| | 234 526 | 2.2 | 3 | 380-415 | 380 | 5.8 | 3100 | 4.0 - 4.9 | 78 | 75 | 46 | 84 | 76 | 64 | 46 | 25 | 10 |
| | | | | | 400 | 5.9 | | | 77 | 73 | 49 | 79 | 70 | 55 | 49 | | |
| | | | | | 415 | 6.3 | | | 76 | 71 | 50 | 74 | 64 | 51 | 50 | | |
| | 234 591 | 3 | 4 | 380-415 | 380 | 7.5 | 4000 | 2.9 - 3.6 | 77 | 78 | 75 | 84 | 76 | 63 | 55 | 25 | 12 |
| | | | | | 400 | 7.8 | | | 78 | 77 | 73 | 78 | 69 | 56 | 58 | | |
| | | | | | 415 | 8.2 | | | 77 | 76 | 71 | 73 | 63 | 50 | 60 | | |
| | 234 527 | 3.7 | 5 | 380-415 | 380 | 9 | 5030 | 2.5 - 3.1 | 76 | 76 | 73 | 84 | 76 | 64 | 72 | 35 | 15 |
| | | | | | 400 | 9.1 | | | 76 | 75 | 71 | 79 | 70 | 70 | 76 | | |
| | | | | | 415 | 9.4 | | | 75 | 74 | 69 | 74 | 65 | 52 | 79 | | |
| | 234 593 | 4 | 5 1/2 | 380-415 | 380 | 9.8 | 5370 | 1.8 - 2.3 | | | | | | | | 45 | 20 |
| | | | | | 400 | 10 | | | 78 | 79 | 76 | 83 | 75 | 62 | 91 | | |
| | | | | | 415 | 10.3 | | | 78 | 77 | 73 | 77 | 67 | 53 | 91 | | |
| | 234 528 | 5.5 | 7 1/2 | 380-415 | 380 | 13.5 | 7430 | 2.5 - 3.1 | 76 | 76 | 73 | 84 | 76 | 64 | 72 | 35 | 15 |
| | | | | | 400 | 13.7 | | | 76 | 75 | 71 | 79 | 70 | 70 | 76 | | |
| | | | | | 415 | 14.2 | | | 75 | 74 | 69 | 74 | 65 | 52 | 79 | | |
| | 234 597 | 7.5 | 10 | 380-415 | 380 | | 9540 | 1.8 - 2.3 | | | | | | | | 45 | 20 |
| | | | | | 400 | 17 | | | 78 | 79 | 76 | 83 | 75 | 62 | 91 | | |
| | | | | | 415 | 17.4 | | | 78 | 77 | 73 | 77 | 67 | 53 | 91 | | |

Performance is typical, not guaranteed, at specified voltages

Performance of 1984 and older models, not listed is similar, but not identical.

**TABLE 16 - 24 Slot Three Phase Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor**

Applicable for Australia/New Zealand

| Type | Motor Model Prefix | Nameplate Rating | | | | | Full Load watts | Line to Line Resistance (Ohms) | Efficiency % | | | Power Factor % | | | Locked Rotor Amps | Circuit Breakers or Fuse Amps<br>Typical Submersible | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kW | HP | Volts | Line Volts | Amps | | | F.L. | 3/4 | 1/2 | F.L. | 3/4 | 1/2 | | Nontime Delay (Std) Fuse or Circuit Breaker | Dual Element Time Delay Fuse |
| 4 Inch | | | | | 380 | 1.1 | 560 | | 66 | 63 | 55 | 0.79 | 0.71 | 0.60 | | | |
| | 234 761 | 0.37 | 1/2 | 380-415 | 400 | 1.1 | 555 | 54.4 -66.4 | 66 | 63 | 54 | 0.74 | 0.66 | 0.55 | 5.61 | 15 | 1.2 |
| | | | | | 415 | 1.14 | 570 | | 65 | 61 | 53 | 0.71 | 0.62 | 0.51 | | | |
| | | | | | 380 | 1.6 | 810 | | 68 | 64 | 57 | 0.79 | 0.71 | 0.60 | | | |
| | 234 762 | 0.55 | 3/4 | 380-415 | 400 | 1.6 | 810 | 41.0 - 52.0 | 68 | 63 | 55 | 0.74 | 0.65 | 0.53 | 7.7 | 15 | 1.8 |
| | | | | | 415 | 1.7 | 840 | | 65 | 60 | 50 | 0.70 | 0.61 | 0.50 | | | |
| | | | | | 380 | 2 | 1065 | | 70 | 69 | 63 | 0.81 | 0.73 | 0.61 | | | |
| | 234 763 | 0.75 | 1 | 380-415 | 400 | 2 | 1075 | 22.2 - 27.2 | 70 | 68 | 61 | 0.77 | 0.68 | 0.55 | 7.3 | 15 | 4 |
| | | | | | 415 | 2.1 | 1085 | | 69 | 66 | 58 | 0.73 | 0.63 | 0.51 | | | |
| | | | | | 380 | 2.8 | 1490 | | 74 | 73 | 68 | 0.82 | 0.75 | 0.63 | | | |
| | 234 724 | 1.1 | 1 1/2 | 380-415 | 400 | 2.8 | 1490 | 13.8 - 16.8 | 74 | 72 | 66 | 0.78 | 0.69 | 0.57 | 16.7 | 15 | 3 |
| | | | | | 415 | 2.9 | 1510 | | 73 | 70 | 64 | 0.74 | 0.65 | 0.52 | | | |
| | | | | | 380 | 3.9 | 2035 | | 73 | 72 | 67 | 0.83 | 0.74 | 0.62 | | | |
| | 234 725 | 1.5 | 2 | 380-415 | 400 | 3.9 | 2035 | 10.9 - 13.4 | 73 | 71 | 65 | 0.78 | 0.68 | 0.55 | 21.5 | 15 | 4.5 |
| | | | | | 415 | 4 | 2060 | | 72 | 69 | 62 | 0.73 | 0.63 | 0.50 | | | |
| | | | | | 380 | 5.4 | 2925 | | 75 | 75 | 71 | 0.82 | 0.74 | 0.60 | | | |
| | 234 726 | 2.2 | 3 | 380-415 | 400 | 5.5 | 2930 | 6.8 - 8.3 | 75 | 74 | 69 | 0.77 | 0.66 | 0.52 | 30.9 | 15 | 7 |
| | | | | | 415 | 5.8 | 2970 | | 74 | 72 | 65 | 0.72 | 0.61 | 0.47 | | | |
| | | | | | 380 | 7.4 | 3915 | | 77 | 77 | 73 | 0.82 | 0.74 | 0.61 | | | |
| | 234 764 | 3 | 4 | 380-415 | 400 | 7.5 | 3930 | 4.7 - 5.8 | 76 | 76 | 70 | 0.77 | 0.67 | 0.53 | 43.6 | 20 | 9 |
| | | | | | 415 | 7.9 | 3980 | | 75 | 73 | 67 | 0.72 | 0.61 | 0.47 | | | |
| | | | | | 380 | 8.8 | 4725 | | 78 | 79 | 75 | 0.83 | 0.75 | 0.62 | | | |
| | 234 727 | 3.7 | 5 | 380-415 | 400 | 9 | 4745 | 3.7 - 4.5 | 78 | 77 | 73 | 0.78 | 0.69 | 0.54 | 54.3 | 25 | 10 |
| | | | | | 415 | 9.3 | 4785 | | 77 | 76 | 70 | 0.73 | 0.63 | 0.49 | | | |
| | | | | | 380 | 9.7 | 5130 | | 78 | 78 | 75 | 0.82 | 0.74 | 0.60 | | | |
| | 234 765 | 4 | 5 1/2 | 380-415 | 400 | 9.9 | 5160 | 3.3 - 4.0 | 78 | 77 | 72 | 0.77 | 0.67 | 0.52 | 59.1 | 25 | 12 |
| | | | | | 415 | 10.4 | 5210 | | 77 | 75 | 69 | 0.72 | 0.61 | 0.47 | | | |
| | | | | | 380 | 12.6 | 6925 | | 79 | 80 | 77 | 0.85 | 0.79 | 0.66 | | | |
| | 234 728 | 5.5 | 7 1/2 | 380-415 | 400 | 12.6 | 6940 | 2.6 - 3.2 | 79 | 79 | 75 | 0.81 | 0.73 | 0.59 | 80.1 | 35 | 15 |
| | | | | | 415 | 12.8 | 7005 | | 79 | 77 | 73 | 0.77 | 0.68 | 0.54 | | | |
| | | | | | 380 | 17.5 | 9475 | | 79 | 80 | 78 | 0.86 | 0.79 | 0.66 | | | |
| | 234 729 | 7.5 | 10 | 380-415 | 400 | 17.1 | 9460 | 1.9 - 2.3 | 79 | 79 | 75 | 0.81 | 0.72 | 0.58 | 103 | 45 | 20 |
| | | | | | 415 | 17.6 | 9530 | | 79 | 78 | 73 | 0.77 | 0.67 | 0.52 | | | |

Performance is typical, not guaranteed, at specified voltages
Performance of 1984 and older models, not listed is similar, but not identical.

# Application - Three-Phase Motors

**TABLE 17 Three-Phase Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor**

| Type | Motor Model Prefix | Nameplate Rating | | | | | Full Load Watts | Line to Line Resistance (Ohms) | Efficiency % | | | Power Factor % | | | Locked Rotor Amps | Circuit Breakers or Fuse Amps – Typical Submersible | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | KW | HP | Volts | Line Volts | Amps** | | | F.L. | 3/4 | 1/2 | F.L. | 3/4 | 1/2 | | Nontime Delay (Std.) Fuse or Circuit Breaker | Dual Element Time Delay Fuse |
| 6 Inch | 236 610 | 3.7 | 5 | 380 -415 | 380 | 8.9 | 4850 | 3.9 - 4.8 | 77 | 76 | 73 | 84 | 78 | 66 | 39 | 25 | 10 |
| | | | | | 400 | 8.8 | 4900 | | 77 | 71 | 59 | 79 | 71 | 59 | 42 | 25 | 10 |
| | | | | | 415 | 9.3 | 4950 | | 75 | 73 | 67 | 74 | 64 | 52 | 43 | 25 | 10 |
| | 236 611 | 5.5 | 7 1/2 | 380 -415 | 380 | 12.7 | 7175 | 2.4 - 2.9 | 78 | 79 | 77 | 85 | 80 | 70 | 61 | 35 | 15 |
| | | | | | 400 | 12.5 | 7100 | | 79 | 78 | 74 | 82 | 75 | 63 | 64 | 35 | 15 |
| | | | | | 415 | 12.8 | 7175 | | 78 | 77 | 74 | 78 | 70 | 57 | 66 | 35 | 15 |
| | 236 612 | 7.5 | 10 | 380 -415 | 380 | 16.5 | 9450 | 1.9 - 2.4 | 79 | 80 | 77 | 87 | 83 | 74 | 83 | 45 | 20 |
| | | | | | 400 | 16.0 | 9450 | | 79 | 79 | 75 | 86 | 80 | 70 | 83 | 45 | 20 |
| | | | | | 415 | 16.2 | 9450 | | 79 | 78 | 75 | 81 | 74 | 62 | 91 | 45 | 20 |
| | 236 613 | 11 | 15 | 380 -415 | 380 | 24.2 | 13750 | 1.1 - 1.4 | 81 | 82 | 80 | 87 | 82 | 72 | 126 | 60 | 30 |
| | | | | | 400 | 23.0 | 13750 | | 81 | 80 | 78 | 84 | 80 | 64 | 125 | 60 | 30 |
| | | | | | 415 | 24.1 | 13750 | | 81 | 80 | 77 | 82 | 75 | 63 | 133 | 60 | 30 |
| | 236 614 | 15 | 20 | 380 -415 | 380 | 32.0 | 18200 | .83 - 1.0 | 82 | 83 | 81 | 87 | 84 | 75 | 164 | 80 | 35 |
| | | | | | 400 | 31.3 | 18500 | | 81 | 81 | 79 | 85 | 80 | 69 | 170 | 80 | 35 |
| | | | | | 415 | 31.0 | 18500 | | 81 | 81 | 77 | 83 | 77 | 65 | 174 | 80 | 35 |
| | 236 615 | 18.5 | 25 | 380 -415 | 380 | 40.0 | 23000 | .62 - .77 | 81 | 83 | 82 | 89 | 85 | 76 | 197 | 100 | 45 |
| | | | | | 400 | 38.5 | 22700 | | 82 | 83 | 81 | 85 | 79 | 68 | 206 | 100 | 45 |
| | | | | | 415 | 38.5 | 22700 | | 82 | 82 | 80 | 82 | 75 | 62 | 215 | 100 | 45 |
| | 236 616 | 22 | 30 | 380 -415 | 380 | 47.0 | 27250 | .52 - .64 | 82 | 83 | 82 | 88 | 86 | 78 | 255 | 125 | 55 |
| | | | | | 400 | 45.3 | 27000 | | 83 | 83 | 81 | 86 | 81 | 71 | 268 | 125 | 55 |
| | | | | | 415 | 45.5 | 27000 | | 83 | 82 | 80 | 84 | 78 | 66 | 278 | 125 | 55 |
| | 236 617 | 30 | 40 | 380 -415 | 380 | 64.1 | 36000 | .34 - .42 | 83 | 84 | 83 | 87 | 82 | 72 | 362 | 175 | 75 |
| | | | | | 400 | 63.5 | 36000 | | 83 | 84 | 82 | 83 | 76 | 64 | 382 | 175 | 75 |
| | | | | | 415 | 64.6 | 36000 | | 83 | 82 | 80 | 79 | 71 | 58 | 397 | 175 | 75 |
| | 276 698 | 37 | 50 | 415 | 415 | 76.6 | 45000 | .34 - .43 | 82 | 84 | 83 | 85 | 90 | 91 | 362 | 200 | 90 |
| | 276 699 | 45 | 60 | 415 | 415 | 87.9 | 54000 | .27 - .35 | 84 | 84 | 82 | 87 | 84 | 76 | 432 | 250 | 110 |
| 8 Inch | 239 600 | 30 | 40 | 380 -415 | 380 | 61.0 | 34700 | .247 - .303 | 86 | 86 | 85 | 88 | 84 | 75 | 397 | 175 | 70 |
| | | | | | 400 | 61.0 | 34700 | | 86 | 86 | 83 | 84 | 78 | 68 | 418 | 175 | 70 |
| | | | | | 415 | 62.0 | 34700 | | 86 | 85 | 82 | 80 | 73 | 62 | 433 | 175 | 70 |
| | 239 601 | 37 | 50 | 380 -415 | 380 | 75.0 | 43000 | .185 - .226 | 87 | 87 | 85 | 89 | 85 | 78 | 507 | 200 | 90 |
| | | | | | 400 | 74.0 | 43000 | | 87 | 87 | 84 | 86 | 81 | 71 | 534 | 200 | 90 |
| | | | | | 415 | 74.0 | 43000 | | 87 | 86 | 83 | 83 | 76 | 66 | 654 | 200 | 90 |
| | 239 602 | 45 | 60 | 380 -415 | 380 | 89.0 | 51500 | .142 - .174 | 87 | 87 | 86 | 89 | 85 | 77 | 612 | 250 | 100 |
| | | | | | 400 | 89.0 | 51500 | | 87 | 87 | 85 | 85 | 81 | 71 | 645 | 250 | 100 |
| | | | | | 415 | 89.0 | 51500 | | 87 | 86 | 84 | 82 | 76 | 65 | 669 | 250 | 100 |
| | 239 603 | 55 | 75 | 380 -415 | 380 | 111.0 | 64000 | .106 - .130 | 88 | 88 | 86 | 89 | 86 | 79 | 819 | 300 | 125 |
| | | | | | 400 | 108.0 | 64000 | | 88 | 87 | 85 | 87 | 82 | 72 | 862 | 300 | 125 |
| | | | | | 415 | 108.0 | 64000 | | 88 | 87 | 84 | 84 | 78 | 66 | 895 | 300 | 125 |
| | 239 604 | 75 | 100 | 380 -415 | 380 | 148.0 | 85000 | .073 - .089 | 88 | 88 | 86 | 89 | 86 | 79 | 1099 | 400 | 175 |
| | | | | | 400 | 145.0 | 86000 | | 87 | 87 | 85 | 87 | 82 | 72 | 1157 | 400 | 175 |
| | | | | | 415 | 145.0 | 86000 | | 87 | 87 | 84 | 84 | 78 | 67 | 1200 | 400 | 175 |
| | 239 105 | 93 | 125 | 380 -415 | 380 | 194.0 | 107000 | .055 - .067 | 87 | 87 | 85 | 86 | 83 | 75 | 1265 | 500 | 225 |
| | | | | | 400 | 190.0 | 107000 | | 87 | 86 | 84 | 83 | 78 | 68 | 1332 | 500 | 225 |
| | | | | | 415 | 191.0 | 107000 | | 87 | 86 | 83 | 80 | 74 | 63 | 1382 | 500 | 225 |
| | 239 106 | 110 | 150 | 380 -415 | 380 | 226.0 | 127000 | .042 - .051 | 88 | 88 | 86 | 87 | 84 | 77 | 1517 | 600 | 300 |
| | | | | | 400 | 222.0 | 127000 | | 88 | 87 | 85 | 84 | 80 | 70 | 1597 | 600 | 300 |
| | | | | | 415 | 223.0 | 127000 | | 88 | 87 | 84 | 81 | 75 | 64 | 1657 | 600 | 300 |
| | 239 107 | 130 | 175 | 380 -415 | 380 | 260.0 | 150000 | .042 - .052 | 87 | 87 | 86 | 89 | 87 | 83 | 1651 | 700 | 300 |
| | | | | | 400 | 252.0 | 148000 | | 88 | 87 | 86 | 87 | 84 | 79 | 1733 | 700 | 300 |
| | | | | | 415 | 247.0 | 148000 | | 88 | 87 | 85 | 86 | 81 | 74 | 1803 | 700 | 300 |
| | 239 108 | 150 | 200 | 380 -415 | 380 | 294.0 | 170000 | .036 - .044 | 88 | 88 | 86 | 90 | 88 | 83 | 1765 | 800 | 350 |
| | | | | | 400 | 284.0 | 170000 | | 88 | 88 | 86 | 88 | 86 | 79 | 1858 | 800 | 350 |
| | | | | | 415 | 277.0 | 170000 | | 88 | 88 | 86 | 87 | 83 | 75 | 1928 | 800 | 350 |

Performance is typical, not guaranteed, at specified voltages.

Locked rotor amps for Wye start 6 lead motors is 33% of value shown.

Performance also applies to 6 lead model numbers where not listed.

Six lead individual phase resistance = table X 1.5.

* Refer to page 48 for 6" Hi Temp 90°C and 8" Hi Temp 75°C motors

** Amps may also be referred to as Full Load Amps (FLA) Service Factor Amps (SFA) or Name Plate Amps

**TABLE 48 Hi Temp 90°C Three-Phase Motor Specifications (50Hz), 2875 RPM, 1.0 Service Factor**

| Type | Motor Model Prefix | Nameplate Rating | | | | | Full Load watts | Line to Line Resistance (Ohms) | Efficiency % | | | Power Factor % | | | Locked Rotor Amps |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | kW | HP | Volts | Line Volts | Amps | | | F.L. | 3/4 | 1/2 | F.L. | 3/4 | 1/2 | |
| 6 INCH HI-Temp 90C | 276 610 | 3.7 | 5 | 380-415 | 380 | 8.8 | 5000 | 2.79 - 3.41 | 74 | 72 | 66 | 88 | 85 | 78 | 49.9 |
| | | | | | 400 | 8.5 | 5000 | | 75 | 72 | 66 | 86 | 82 | 74 | 52.5 |
| | | | | | 415 | 8.4 | 5000 | | 75 | 72 | 65 | 84 | 79 | 70 | 54.5 |
| | 276 611 | 5.5 | 7.5 | 380-415 | 380 | 12.7 | 7300 | 1.66 - 2.03 | 77 | 75 | 70 | 88 | 85 | 77 | 78.6 |
| | | | | | 400 | 12.3 | 7200 | | 77 | 75 | 70 | 86 | 81 | 72 | 83.0 |
| | | | | | 415 | 12.3 | 7200 | | 77 | 75 | 69 | 84 | 77 | 67 | 86.0 |
| | 276 612 | 7.5 | 10 | 380-415 | 380 | 16.4 | 9400 | 1.18 - 1.44 | 80 | 78 | 74 | 88 | 84 | 76 | 105 |
| | | | | | 400 | 16.0 | 9300 | | 81 | 79 | 74 | 85 | 79 | 69 | 110 |
| | | | | | 415 | 16.1 | 9400 | | 80 | 77 | 71 | 83 | 76 | 65 | 114 |
| | 276 613 | 11 | 15 | 380-415 | 380 | 24.4 | 13900 | .78 - .96 | 80 | 79 | 75 | 85 | 83 | 74 | 152 |
| | | | | | 400 | 24.2 | 13800 | | 80 | 79 | 74 | 82 | 77 | 67 | 160 |
| | | | | | 415 | 24.4 | 14000 | | 79 | 78 | 73 | 79 | 73 | 61 | 166 |
| | 276 614 | 15 | 20 | 380-415 | 380 | 33.3 | 18700 | .58 - .72 | 80 | 79 | 76 | 87 | 82 | 73 | 195 |
| | | | | | 400 | 33.0 | 18700 | | 80 | 79 | 75 | 83 | 77 | 65 | 205 |
| | | | | | 415 | 33.3 | 18700 | | 80 | 78 | 74 | 80 | 72 | 60 | 213 |
| | 276 615 | 18.5 | 25 | 380-415 | 380 | 40.7 | 22600 | .41 - .51 | 82 | 82 | 79 | 86 | 80 | 70 | 253 |
| | | | | | 400 | 40.5 | 22500 | | 83 | 82 | 78 | 82 | 74 | 62 | 266 |
| | | | | | 415 | 41.4 | 22700 | | 82 | 80 | 76 | 78 | 69 | 57 | 276 |
| | 276 616 | 22 | 30 | 380-415 | 380 | 49.2 | 27800 | .34 - .42 | 80 | 79 | 76 | 88 | 83 | 76 | 289 |
| | | | | | 400 | 48.0 | 27700 | | 81 | 79 | 75 | 85 | 80 | 70 | 304 |
| | | | | | 415 | 47.9 | 27800 | | 80 | 79 | 74 | 82 | 76 | 65 | 316 |
| | 276 617 | 30 | 40 | 380-415 | 380 | 65.0 | 35900 | .23 - .29 | 83 | 82 | 80 | 86 | 80 | 70 | 419 |
| | | | | | 400 | 64.5 | 35800 | | 83 | 82 | 79 | 82 | 75 | 63 | 441 |
| | | | | | 415 | 65.6 | 36000 | | 83 | 81 | 77 | 78 | 70 | 58 | 458 |
| 8 INCH HI-Temp 75C | 279 100 | 30 | 40 | 380-415 | 380 | 66.8 | 37000 | .16 - .19 | 80 | 78 | 72 | 0.86 | 0.82 | 0.76 | 474 |
| | | | | | 400 | 65.5 | 37000 | | 80 | 78 | 72 | 0.83 | 0.78 | 0.7 | 499 |
| | | | | | 415 | 65.8 | 37000 | | 80 | 77 | 71 | 0.8 | 0.74 | 0.65 | 518 |
| | 279 101 | 37 | 50 | 380-415 | 380 | 80.7 | 45000 | .11 - .14 | 83 | 80 | 75 | 0.87 | 0.83 | 0.76 | 654 |
| | | | | | 400 | 79.6 | 45000 | | 82 | 80 | 74 | 0.84 | 0.79 | 0.7 | 692 |
| | | | | | 415 | 80.1 | 46000 | | 82 | 79 | 73 | 0.81 | 0.75 | 0.65 | 720 |
| | 279 102 | 45 | 60 | 380-415 | 380 | 94.3 | 53000 | .09 - .11 | 85 | 83 | 78 | 0.87 | 0.82 | 0.75 | 835 |
| | | | | | 400 | 93.1 | 53000 | | 84 | 82 | 77 | 0.84 | 0.78 | 0.69 | 884 |
| | | | | | 415 | 93 | 53000 | | 84 | 82 | 76 | 0.81 | 0.74 | 0.64 | 920 |
| | 279 103 | 55 | 75 | 380-415 | 380 | 118 | 67000 | .07 - .09 | 84 | 82 | 78 | 0.87 | 0.84 | 0.77 | 876 |
| | | | | | 400 | 115 | 66000 | | 84 | 82 | 78 | 0.85 | 0.81 | 0.72 | 927 |
| | | | | | 415 | 113 | 66000 | | 84 | 82 | 77 | 0.83 | 0.78 | 0.69 | 965 |
| | 279 104 | 75 | 100 | 380-415 | 380 | 155 | 87000 | .05 - .07 | 85 | 84 | 81 | 0.87 | 0.83 | 0.76 | 1185 |
| | | | | | 400 | 151 | 87000 | | 86 | 84 | 80 | 0.85 | 0.8 | 0.71 | 1254 |
| | | | | | 415 | 150 | 87000 | | 85 | 84 | 80 | 0.82 | 0.76 | 0.66 | 1306 |
| | 279 105 | 93 | 125 | 380-415 | 380 | 191 | 109000 | .04 - .06 | 86 | 85 | 81 | 0.88 | 0.85 | 0.78 | 1404 |
| | | | | | 400 | 186 | 109000 | | 86 | 84 | 81 | 0.86 | 0.8 | 0.73 | 1482 |
| | | | | | 415 | 184 | 109000 | | 86 | 84 | 80 | 0.84 | 0.76 | 0.69 | 1544 |
| | 279 106 | 110 | 150 | 380-415 | 380 | 231 | 131000 | .03 - .05 | 85 | 84 | 81 | 0.88 | 0.84 | 0.77 | 1596 |
| | | | | | 400 | 224 | 130000 | | 86 | 84 | 81 | 0.85 | 0.81 | 0.72 | 1690 |
| | | | | | 415 | 222 | 130000 | | 86 | 84 | 80 | 0.83 | 0.77 | 0.68 | 1760 |

Performance is typical, not guaranteed, at specified voltages. Locked rotor amps for Wye start 6 lead motors is 33% of value shown. Performance also applies to 6 lead model numbers where not listed. Six lead individual phase resistance = table X 1.5.

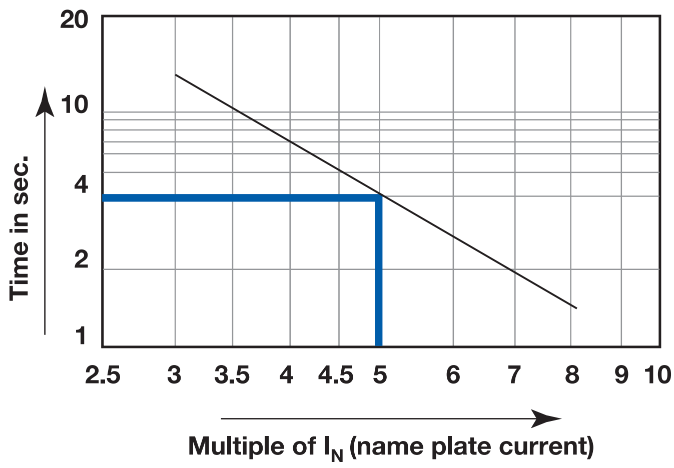
## Overload Protection of Three-Phase Submersible Motors

### Motor Protection, Selection of Thermal Overload Relays

Characteristics of submersible motors differ from standard motors and special overload protection is required. In order to provide sufficient protection against overload and locked rotor, the relay has to be of the following characteristic:

- Conform to European standards e.g. VDE providing trip time <10 sec. at 500% $I_N$ (name plate current) based on cold bimetal
- Protection against single phasing
- Must trip at 120% $I_N$ (name plate current)
- Temperature compensated to avoid nuisance tripping

The specific information can be obtained directly from the manufacturer's catalog. They are available from a Current/Time curve as shown on the right.




### Overload setting, DOL and YΔ start

For DOL, max. at full current $I_N$ shown on nameplate.

For YΔ, relay must be incorporated in the delta circuit for adequate protection on Y start and set at $I_N$ x 0.58.

Recommended setting for all applications is the measured current value at duty point.

Setting > $I_N$ is not allowed.

# Application - Three-Phase Motors

## SubMonitor Three-Phase Protection

### Applications

SubMonitor is designed to protect 3-phase pumps/motors with service factor amp ratings (SFA) from 5 to 350 A (approx. 2.2-150kW). Current, voltage, and motor temperature are monitored using all three legs and allows the user to set up the SubMonitor quickly and easily.

### Protects Against

- Under/Overload
- Under/Overvoltage
- Current Unbalance
- Overheated Motor
  (if equipped with Subtrol Heat Sensor)
- False Start (Chattering)
- Phase Reversal


## 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 19 KVAR Required 50 Hz**

| Motor | | KVAR Required for P.F. of: | | |
|---|---|---|---|---|
| KW | HP | 0.90 | 0.95 | 1.00 |
| 3.7 | 5 | .8 | 1.5 | 3.1 |
| 5.5 | 7 1/2 | 1.0 | 2.1 | 4.5 |
| 7.5 | 10 | .8 | 2.2 | 5.3 |
| 11 | 15 | 1.1 | 3.3 | 7.8 |
| 15 | 20 | 1.8 | 4.3 | 9.6 |
| 18.5 | 25 | 3 | 6.5 | 14 |
| 22 | 30 | 3 | 7.5 | 17 |
| 30 | 40 | 5 | 10 | 22 |
| 37 | 50 | 5 | 12 | 27 |
| 45 | 60 | 5 | 13 | 30 |
| 55 | 75 | 5 | 15 | 37 |
| 75 | 100 | 4 | 18 | 46 |
| 90 | 125 | 18 | 35 | 72 |
| 110 | 150 | 18 | 38 | 82 |
| 130 | 175 | 13 | 37 | 88 |
| 150 | 200 | 10 | 37 | 95 |

Values listed are total required (not per phase).

## 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.

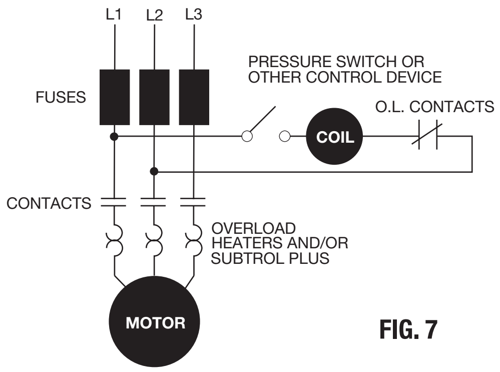



FIG. 7

### 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.

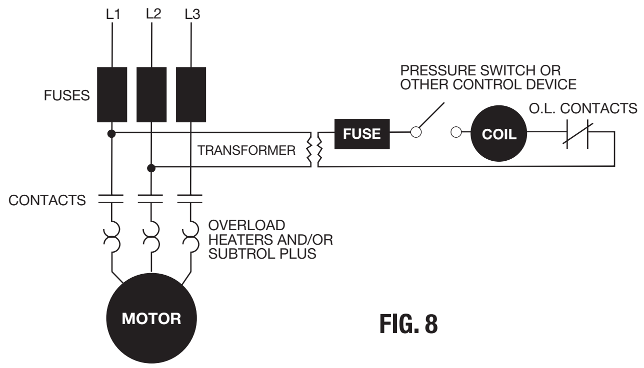



FIG. 8

### 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.

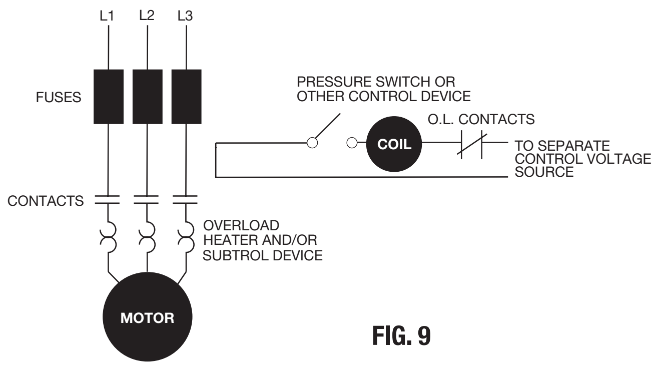



FIG. 9

## 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

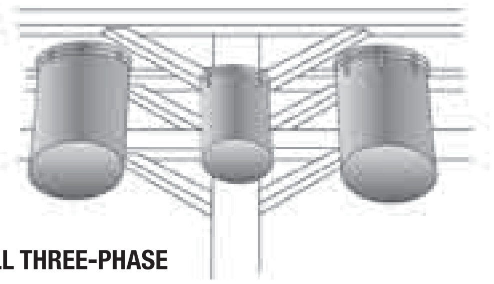


**FIG. 10 FULL THREE-PHASE**

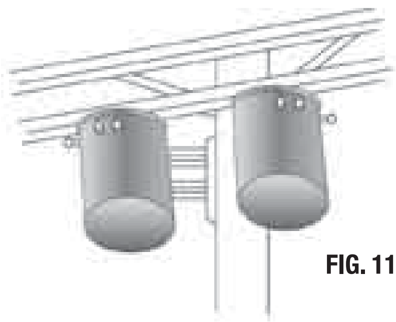


**FIG. 11 OPEN DELTA**

## Three-Phase Power 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:

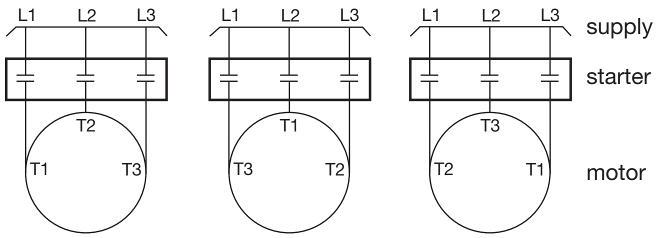
   A. Add the three line amps values together.

   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 full 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 = 51 amps | T3 = 50 amps | T2 = 50 amps |
| T2 = 46 amps | T1 = 49 amps | T3 = 48 amps |
| + T3 = 53 amps | + T2 = 51 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 - 46 = 4 amps | 50 - 49 = 1 amp | 50 - 48 = 2 amps |
| $\frac{4}{50}$ = .08 or 8% | $\frac{1}{50}$ = .02 or 2% | $\frac{2}{50}$ = .04 or 4% |

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

To reverse rotation, interchange any two leads.

Phase 1 or “A”- T1, or U1

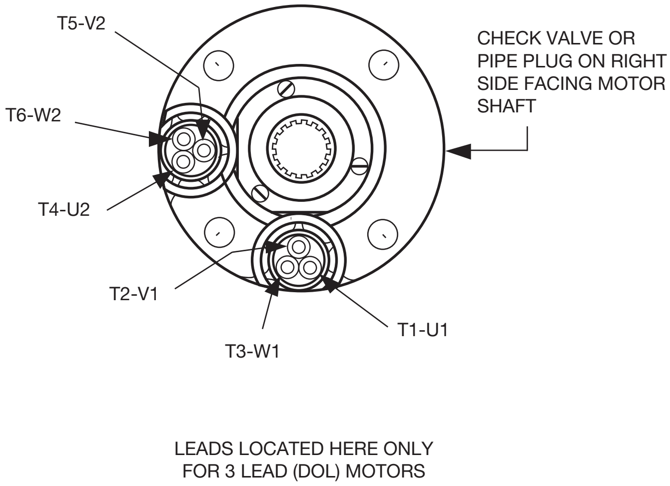
Phase 2 or “B”- T2, or V1

Phase 3 or “C”- T3, or W1

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

## Three-Phase Motor Lead Identification

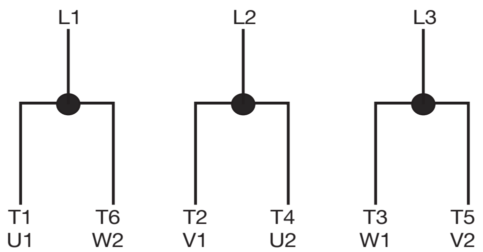
### 90° Lead Spacing




### Line Connections — Six Lead Motors

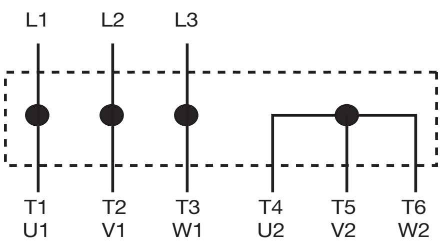
**DOL or SD RUNNING**

Connections for across-the-line starting, running, and any reduced voltage starting except YD/SD type starters.




**SD STARTING**

YD/SD 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.

* Star Delta (SD) is the same as Wye Delta (YD)

## 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 motor current goes from zero to locked rotor amps, then 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.

In some cases the power companies may require reduced-voltage starters to limit this voltage dip. There are also times when reduced-voltage starters may be desirable to reduce motor starting torque thus reducing the stress on shafts, couplings, and discharge piping. Reduced-voltage starters also slow the rapid acceleration of the water on start up to help control up thrust and water hammer.

Reduced-voltage starters may not be required if the maximum recommended cable length is used. With maximum recommended cable length there is a 5% voltage drop in the cable at running amps, resulting in about 20% reduction in 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 are not required.

**Three-Lead Motors:** Autotransformer or solid-state reduced-voltage starters may be used for soft-starting standard three-phase motors.

When autotransformer starters are used, the motor should be supplied with at least 55% of rated voltage to ensure adequate starting torque. Most autotransformer starters have 65% and 80% 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 starters cannot be used with SubMonitor unless a bypass contactor is installed across the starter. Consult the factory for details.**

**Six-Lead Motors:** 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 compatible with Franklin Electric submersible motors and should not be used.

Wye-Delta starters of the open-transition type, which momentarily interrupt power during the starting cycle, are not recommended. Closed-transition starters have no interruption of power during the start cycle and can be used with satisfactory results.

**Reduced-voltage starters have adjustable settings for acceleration ramp time, typically preset at 30 seconds. They must be adjusted so the motor is at full voltage within THREE SECONDS MAXIMUM to prevent excessive radial and thrust bearing wear.**

**If SubMonitor is used the acceleration time must be set to TWO SECONDS MAXIMUM due to the fast reaction time of the SubMonitor.**

## In-line Booster Pump Systems

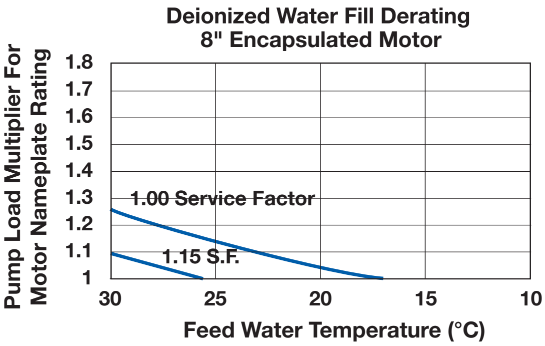
Franklin Electric's submersible motors are acceptable for booster pumps, up to 93kW (125HP) motor shaft output, using an open or closed system flow sleeve provided the following conditions are taken into consideration in the system design.

### Design And Operational Requirements

1. **Non-Vertical Operation:** Vertical Shaft-up (0°) to Horizontal (90°) operation is acceptable as long as the pump transmits "down-thrust" to the motor within 3 seconds after start-up and continuously during operation. However, it is best practice to provide a positive slope whenever it is possible, even if it is only a few degrees.
2. **Motor, Sleeve, and Pump Support System:** The booster sleeve I.D. must be sized according to the motor cooling and pump NPSHR requirements. The support system must support the motor's weight, prevent motor rotation and keep the motor and pump aligned. The support system must also allow for thermal axial expansion of the motor without creating binding forces.
3. **Motor Support Points:** A minimum of two support points are required on the motor. One in the motor/pump flange connection area and one in the bottom end of the motor area. The motor castings, not the shell area, are recommended as support points. If the support is a full length support and/or has bands in the shell area, they must not restrict heat transfer or deform the shell.
4. **Motor Support Material and Design:** The support system should minimize turbulence, vibration, and flow restrictions. The support materials and locations must not inhibit the heat transfer away from the motor.
5. **Motor and Pump Alignment:** The maximum allowable misalignment between the motor, pump, and pump discharge is 0.025 inch per 12 inches of length (2mm per 1000mm of length). This must be measured in both directions along the assembly using the motor/pump flange connection as the starting point. The booster sleeve and support system must be rigid enough to maintain this alignment during assembly, shipping, operation and maintenance.

## In-line Booster Pump Systems (continued)

6. **Motor Fill Solution Exchange To Deionized Water:** Refilling of the motor with Deionized (DI) water should be done only if the application absolutely requires it. Applications requiring DI water must comply with the below derating chart. The exchange of the motor fill solution must be done by an approved Franklin Electric service shop or representative. The motor must be permanently stamped with a "D" closely behind the Serial Number located above the motor nameplate. The maximum pressure that can be applied to the motor internal components during the flushing and refilling process is 7 psi (0.5 bar).




**First:** Determine maximum Feed Water Temperature that will be experienced in this application.

**Second:** Determine the Pump Load Multiplier from the appropriate Service Factor curve. (Typical 1.15 Service Factor is for 60Hz ratings & 1.00 Service Factor ss for 50Hz ratings.)

**Third:** Multiply the Pump Load Requirement by the Pump Load Multiplier to determine the Minimum Motor Nameplate Rating.

**Fourth:** Select a motor with an equal or higher motor nameplate rating.

7. **Motor Alterations - Sand Slinger & Check Valve Plug:** On 6" and 8" motors, the rubber sand slinger located on the shaft must be removed. The pipe plug covering the check valve must be removed from Ni-resist and 316 SS motors.

8. **Frequency of Starts:** Fewer than 10 starts per 24-hour period are recommended. Allow at least 20 minutes between shutdown and start-up of the motor.

9. **Controls - Soft Starters and VFDs:** Reduced voltage starters and variable speed drives (inverter drives) may be used with Franklin three-phase submersible motors to reduce starting current, upthrust, and mechanical stress during start-up. The guidelines for their use with submersible motors are different than with normal air cooled motor applications. Refer to the Franklin Electric Application, Installation and Maintenance (AIM) Manual Reduced Voltage Starters section or Variable Speed Submersible Pump Operation, Inverter Drives sections for specific details.

10. **Motor Overload Protection:** Submersible motors require properly sized ambient compensated Class 10 quick-trip overloads per the Franklin's AIM Manual guidelines to protect the motor. Class 20 or higher overloads are **NOT** acceptable. Franklin's SubMonitor is strongly recommended for all large submersibles since it is capable of sensing motor heat without any additional wiring to the motor. Applications using Soft Starters with a SubMonitor require a start-up bypass - consult the factory for details. SubMonitor can not be used in applications using a VFD control.

11. **Motor Surge Protection:** Properly sized, grounded and dedicated motor surge arrestors must be installed in the supply line of the booster module as close to the motor as possible. This is required on all systems including those using soft-starters and variable speed drives (inverter drives).

12. **Wiring:** Franklin's lead assemblies are only sized for submerged operation in 30°C or less water and may overheat and cause failure or serious injury if operated in air. Any wiring not submerged must meet applicable national and local wiring codes and Franklin Cable Chart Table 24. (Notice: wire size, wire rating and insulation temperature rating must be known when determining its suitability to operate in air or conduit. Typically, for a given size and rating, as the insulation temperature rating increases its ability to operate in air or conduit also increases.)

**TABLE 24 Franklin Cable chart (See 12. Wiring)**

| Cable Temp. Rating (°C) | Motor Nameplate Rated Amps Full Load | #10 AWG | | #8 AWG | | #6 AWG | | #4 AWG | | #2 AWG | | Source of Cable Ampacity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | In Air | In Conduit | In Air | In Conduit | In Air | In Conduit | In Air | In Conduit | In Air | In Conduit | |
| 75 | 3-Lead (DOL) | 40A | 28A | 56A | 40A | 76A | 52A | 100A | 68A | 136A | 92A | US N.E.C., 2002 edition, Tables 310.16 & 310.17 |
| | 6-Lead (Y-Δ) | 69A | 48A | 97A | 69A | 132A | 90A | 173A | 118A | 236A | 159A | |
| 90 | 3-Lead (DOL) | 44A | 32A | 64A | 44A | 84A | 60A | 112A | 76A | 152A | 104A | US N.E.C., 2002 edition, Tables 310.16 & 310.17 |
| | 6-Lead (Y-Δ) | 76A | 55A | 111A | 76A | 145A | 104A | 194A | 132A | 263A | 180A | |
| 135 | 3-Lead (DOL) | 63A | 46A | 74A | 51A | 104A | 74A | 145A | 98A | 185A | 126A | Standard AAR (American Association of Railroads) RP-585 |
| | 6-Lead (Y-Δ) | 109A | 80A | 127A | 88A | 180A | 129A | 251A | 170A | 320A | 219A | |

Based on 30°C maximum ambient with cable length of 100 feet or less

## In-line Booster Pump Systems (continued)

13. **Check Valves:** Spring-loaded check valves must be used on start-up to minimize motor upthrusting, water hammer, or in multiple booster (parallel) applications to prevent reverse flow.
14. **Pressure Relief Valves:** A pressure relief valve is required and must be selected to ensure as the pump approaches shut-off that it never reaches the point that the motor will not have adequate cooling flow past it.
15. **System Purge (Can Flooding):** An air bleeder valve must be installed on the booster sleeve so that flooding may be accomplished prior to booster start-up. Once flooding is complete, the booster should be started and brought up to operating pressure as quickly as possible to minimize the duration of an upthrust condition.
16. **System Flush – Must Not Spin Pump:** Applications may utilize a low flow flushing operation. Flow through the booster sleeve **must not** spin the pump impellers and the motor shaft. If spinning takes place, the bearing system will be permanently damaged and the motor life shortened. Consult the booster pump manufacturer for maximum flow rate through the pump when the motor is not energized.
17. **Open Atmosphere Booster Pump Systems:** When an open booster is placed in a lake, tank, etc. that is open to atmospheric pressure, the water level must provide sufficient head pressure to allow the pump to operate above its NPSHR requirement at all times and all demand or seasonal levels. Adequate inlet pressure must be provided prior to booster start-up.

### Continuous Monitoring System Requirements Four Factors Minimum

1. **Water Temperature:** Feed water on each booster must be continuously monitored and not allowed to exceed 86°F (30°C) at any time. IF THE INLET TEMPERATURE EXCEEDS 86°F (30°C), THE SYSTEM MUST SHUTDOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE. If feed water temperatures are expected to be above 86°F (30°C), the motor must be derated. See Franklin's AIM Manual Hot Water Applications section for derating guidelines. (The high temperature feed water derating is in addition to any DI water derating if one was required.)
2. **Inlet Pressure:** The inlet pressure on each booster must be continuously monitored and not allowed to drop below 20 PSIG at any time. If the pump's specified Net Positive Suction Head Requirement (NPSHR) is greater than 20 PSIG, increase the inlet pressure requirement to the greater value. Adequate inlet pressure must be provided prior to booster start-up. IF THE INLET PRESSURE DROPS BELOW THE INLET PRESSURE REQUIREMENT, THE SYSTEM MUST SHUTDOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE. NOTE: Motors where the inlet pressure exceeds 500 PSI must undergo special high pressure testing. Consult factory for details and availability.
3. **Discharge Flow:** The flow rate for each pump must not be allowed to drop below the motor minimum cooling flow requirement. IF THE MOTOR MINIMUM COOLING FLOW REQUIREMENT IS NOT BEING MET, THE SYSTEM MUST BE SHUTDOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE.
4. **Discharge Pressure:** The discharge pressure must be monitored to maintain a down thrust load toward the motor within 3 seconds after start-up and continuously during operation. IF THE MOTOR DISCHARGE PRESSURE IS NOT ADEQUATE TO SUPPLY DOWN THRUST, THE SYSTEM MUST BE SHUTDOWN IMMEDIATELY TO PREVENT PERMANENT MOTOR DAMAGE.

## 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.

**Frequency Range:** Continuous between 30 Hz and rated frequency (50 or 60 Hz). Operations above rated frequency require special considerations, consult factory for details.

**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.

**Voltage Rise-time or dV/dt:** Limit the peak voltage to the motor to 1000V and keep the rise-time greater than 2 µsec. Alternately stated: keep dV/dt < 500V/µsec. See Filters or Reactors.

## Variable Speed Submersible Pump Operation, Inverter Drives (continued)

**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.

**Motor Overload Protection:** Protection in the drive (or separately furnished) must be set to trip within 10 seconds at 5 times motor maximum nameplate amps in any line, and ultimately trip within 115% of nameplate maximum amps in any line.

**SubMonitor:** Franklin's SubMonitor protection systems ARE NOT USABLE on VFD installations.

**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 all three of the following conditions are met: (1) Voltage is 380 or greater and (2) Drive uses IGBT or BJT switches (rise-times < 2 μsec) and (3) Cable from drive to motor is more than 15.2 m. 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 unless a reactor is used. If a long cable is used with a reactor, additional voltage drop will occur between the VFD and the motor. To compensate, set the VFD output voltage higher than the motor rating in proportion to the reactor impedance (102% voltage for 2% impedance, etc.).

**Motor Cooling Flow:** For installations that are variable-flow, variable-pressure, minimum flow rates must be maintained at nameplate frequency. In variable-flow, constant pressure installations, minimum flow rates must be maintained at the lowest flow condition. Franklin's minimum flow requirements for 4" motors: 7.26 cm/sec. and for 6" and 8" motors: 15.24 cm/sec.

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

**Miscellaneous:** Franklin three-phase motors are not declared "Inverter Duty" motors per NEMA MG1, Part 31 standards. However, Franklin's submersible motors can be used with VFDs without problems and/or warranty concerns provided these guidelines are followed.

# Application - SubDrive/MonoDrive Series

## Circuit Breaker and Maximum Input Cable Lenghts - Power supply to Controller( metres)

| AWG Copper Wire Sizes, 167 °F/75°C Insulation Unless Otherwise Noted | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Model Series | Breaker Amps | Volts | mm² | 2.5 | 4 | 6 | 10 | 16 | 25 | 35 | 35 | 50 | 70 | 95 |
| MonoDrive | 15 | 208 | | 20 | 35 | 60 | 95 | 150 | 240 | 295 | 390 | 495 | | |
| | 15 | 230 | | 25 | 45 | 75 | 115 | 185 | 295 | 365 | 480 | 610 | | |
| Subdrive75 | 15 | 208 | | 20 | 30 | 55 | 85 | 165 | 215 | 265 | 350 | 445 | | |
| | 15 | 230 | | 25 | 40 | 65 | 105 | 165 | 260 | 325 | 430 | 545 | | |
| MonoDriveXT | 20 | 208 | | | 25 | 40 | 65 | 105 | 165 | 205 | 270 | 345 | | |
| | 20 | 230 | | | 30 | 50 | 80 | 125 | 200 | 250 | 330 | 420 | | |
| Subdrive100 | 25 | 208 | | | | 35 | 55 | 85 | 135 | 165 | 220 | 280 | | |
| | 20 | 230 | | | 25 | 40 | 65 | 105 | 165 | 205 | 270 | 340 | | |
| Subdrive150 | 30 | 208 | | | | 25 | 40 | 70 | 110 | 140 | 180 | 230 | | |
| | 25 | 230 | | | | 35 | 55 | 85 | 135 | 170 | 225 | 285 | | |
| Subdrive300 | 40 | 208 | | | | | | 45 | 70 | 90 | 115 | 145 | 185 | 220 |
| | 40 | 230 | | | | | 35 | 55 | 85 | 110 | 140 | 180 | 225 | 270 |
| XXXX | Highlighted Numbers denote wire with 194 °F/90 °C insulation only. | | | | | | | | | | | | | |

## Maximum Motor Cable Lengh ( Metres)

| | HP | kW | 14 | 12 | 10 | 8 | 6 | 4 |
|---|---|---|---|---|---|---|---|---|
| | | | 2.5 | 4 | 6 | 10 | 16 | 25 |
| SubDrive 75 | 1.5 | 1.1 | 130 | 200 | 320 | 500 | | |
| SubDrive 150 | 3 | 2.2 | 70 | 115 | 185 | 300 | 465 | |
| SubDrive 300 | 5 | 3.7 | | 70 | 110 | 180 | 280 | 435 |
| MonoDrive | 0.5 | 0.37 | 120 | 195 | 310 | 490 | | |
| | 0.75 | 0.55 | 90 | 145 | 230 | 365 | 565 | |
| | 1 | 0.75 | 75 | 120 | 190 | 300 | 465 | |
| MonoDrive XT | 1.5 | 1.1 | 55 | 90 | 145 | 230 | 365 | 565 |
| | 2 | 1.5 | 45 | 75 | 115 | 185 | 295 | 465 |

A - 3.3 metre (10 ft) section of cable is provided with the Subdrive/MonoDrive to connect the pressure sensor. ( If additional cable is required a "0.3mm²" (22 AWG) x 30 metres
Maximum allowable wire lengths are measured between the controller and motor
Aluminum wires should not be used with the SubDrive/MonoDrive.
Orange circular drop - electrical cable is not rated for submersible use. Warranty void if used.
All wiring to comply with AS/NSZ3000 and National Electrical Codes and /or local codes.
MonoDrive minimum breaker amps may be lower than 50 Hz AIM Manual specifications for the motors listed due to the soft-starting characteristic of the MonoDrive controller.
SubDrive minimum breaker amps may apperar to exceed 50 Hz AIM Manual specifications for the motors listed because SubDrive controllers are supplied from a single-phase service rather than three phase.

## Three Phase SubDrive Motors Specifications (60Hz)

| | kW | HP | Volts | S.F | Full Load | | Max- S.F load | | Line to Line Resistance Ohms | Locked Rotor Amps |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Amps | Watts | Amps | Watts | | |
| SubDrive 75 | 1.1 | 1,5 | 230 | 1.3 | 5 | 1460 | 5.9 | 1890 | 3.2 - 4.0 | 33.2 |
| SubDrive 150 | 2.2 | 3 | 230 | 1.15 | 9.5 | 2980 | 10.9 | 3420 | 1.8 - 2.2 | 61.9 |
| SubDrive 300 | 3.7 | 5 | 230 | 1.15 | 15.9 | 5050 | 17.8 | 5810 | 1.0 - 1.2 | 106 |

| SubDrive Motor Leads | |
|---|---|
| Series | Part No. |
| 75 | 310 113 401 |
| 150 / 300 | 308 013 702 |

In addition to improved system protection, Franklin Electric's SubDrive and MonoDrive systems use electronic reduced voltage starting or "soft start" technology. This technology allows the use of smaller generators than those used on conventional systems.

| Recommended minimum generator sizes: | | |
|---|---|---|
| MonoDrive | KW | KVA |
| ½ Hp - 0.37 kW | 2 | 2.5 |
| ¾ Hp - 0.55 kW | 3 | 3.75 |
| 1 Hp - 0.75 kW | 3.5 | 4.37 |
| MonoDrive XT | | |
| 1 ½ Hp - 1.1 kW | 4 | 5 |
| 2 Hp - 1.5 kW | 5 | 6.25 |
| SubDrive Series | | |
| SDQP - 75 | 3.5 | 4.37 |
| SDQP - 150 | 7 | 8.75 |
| SDQP - 300 | 11 | 13.75 |

## Dip Switch Settings

| SDQP 75 Series Order No. | SD Pump End | dip.sw No1 | dip.sw No 2 | dip.sw No 3 | dip.sw No 4 |
|---|---|---|---|---|---|
| SDQP 75 25-160 | 93870708 | OFF | OFF | ON | ON |
| SDQP 75 30-135 | 93871008 | OFF | OFF | ON | ON |
| SDQP 75 45-105 | 93871508 | OFF | OFF | ON | ON |
| SDQP 75 60-83 | 93872008 | OFF | OFF | ON | ON |
| SDQP 75 70-82 | 93872511 | OFF | ON | ON | ON |
| SDQP 75 100-55 | 93873511 | OFF | ON | ON | ON |
| **SDQP 150 Series** | | | | | |
| SDQP 150 25-300 | 93870716 | OFF | OFF | ON | ON |
| SDQP 150 30-245 | 93871016 | OFF | OFF | ON | ON |
| SDQP 150 45-195 | 93871516 | OFF | OFF | ON | ON |
| SDQP 150 60-155 | 93872016 | OFF | OFF | ON | ON |
| SDQP 150 65-137 | 93872516 | OFF | OFF | ON | ON |
| SDQP 150 100-94 | 93873516 | OFF | OFF | ON | ON |
| SDQP 150 150-65 | 93874516 | OFF | OFF | ON | ON |
| **SDQP 300 Series** | | | | | |
| SDQP 300 30-400 | 93871031 | OFF | OFF | OFF | ON |
| SDQP 300 45-335 | 93871531 | OFF | OFF | OFF | ON |
| SDQP 300 60-265 | 93872031 | OFF | OFF | OFF | ON |
| SDQP 300 70-240 | 93872531 | OFF | OFF | OFF | ON |
| SDQP 300 100-165 | 93873531 | OFF | OFF | OFF | ON |
| SDQP 300 150-118 | 93874531 | OFF | OFF | OFF | ON |
| SDQP 300 200-82 | 93876031 | OFF | OFF | OFF | ON |
| SDQP 300 270-60 | 93879031 | OFF | OFF | OFF | ON |

SubDrive controller dip switch settings are per set prior to shipment on all new SubDrive Quick Pak systems.

### SubDrive/MonoDrive DIP Switches:

One of the best things about Franklin Electric's SubDrive and MonoDrive products is that they can be used in a variety of applications, such as residential, agricultural, irrigation and commercial. Franklin Electric has increased the flexibility of these products by providing internal DIP switches. This section of Franklin AIM's manual will explain DIP switches and what they mean to you, the professional water systems contractor.

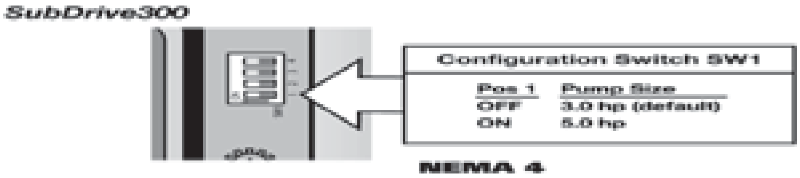
**CAUTION:** Serious or fatal electric shock may result from contact with internal components. DO NOT, under any circumstance , attempt to modify DIP switch settings until power has been removed, five minutes have passed and internal voltage has discharged. Power must be removed. Power must be removed for DIP switch settings to take effect.

The SubDrive and MonoDrive DIP switch package is labeled SW1, and each individual switch also is labeled. The four switches can be set in one of two positions (ON or OFF) and control different aspects of the system. A small screwdriver comes packaged with each product to aid in switch setting, due to the size of the switches. In most cases, the DIP switch setting will not need to be changed, with the exception of setting the pump size for MonoDrive and MonoDriveXT. Let's take a look at each of the switches in SubDrive and MonoDrive and see how they work.

## Dip Switch Settings cont

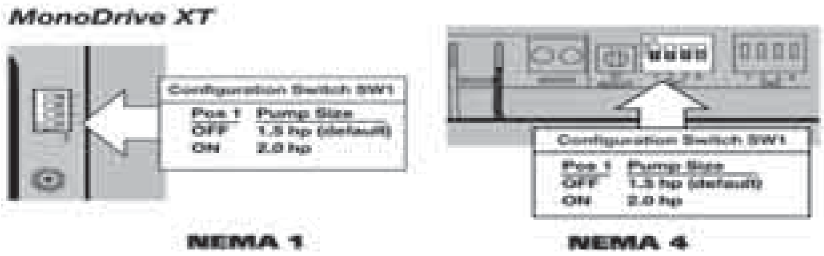
### Switches 1 and 2

Switches 1 and 2 of the package tell the SubDrive or MonoDrive controller which pump is attached to the motor. For example: on a SubDrive75, a ¾ horsepower pump would normally be coupled to a 1.5 horsepower 3-phase motor. In this case, the first two switches are set in the OFF position. (This is the default setting.) However, in some cases, you might want to use a 1 or a 1.5 horsepower pump. This can be done, but you need to tell the SubDrive controller there is a different pump in place. If a 1 horsepower pump were to be used, switch 1 will remain OFF and 2 must be changed to ON. If a 1.5 horsepower pump were to be used, switch 1 must be moved to the ON position and 2 will remain OFF. In the case of other SubDrive models, switches 1 and 2 are used in a very similar way. Refer to the installation manual for the details.


MonoDrive is designed to be used with a ½, ¾, or 1 horsepower single-phase 3-wire motor and pump. However, because of these options, it is critical to tell the MonoDrive controller what is in the well. As in the case of SubDrive, positions 1 and 2 on SW1 are used. The switch positions for each are shown in the following illustrations.


MonoDrive XT works in very much the same way




### Switch 3 - Underload Sensitivity

All SubDrive/MonoDrive products offer built-in underload protection. The most common reason for an underload is an out-of-water condition. The SubDrive/MonoDrive controller is configured at the factory to ensure detection of underload faults in a wide variety of pumping applications. In rare cases, the underload trip level may be too sensitive. The most likely application for this scenario will be a shallow well.

If you are installing SubDrive/MonoDrive in a shallow well, it is a good idea to observe how the system behaves at various flow rates. Move switch 3 on SW1 ot ON if you see nuisance tripping. However, before doing this, make sure that you're truly seeing a nuisance fault, and not an actual out-of-water condition. What we've just discussed applies to all SubDrive and MonoDrive products. That is, the underload sensitivity is located in the same place and functions in the same way.

### Switch 4 - Sensitivity

Although in most cases pressure regulation will be completely stable, in certain conditions the controller's pressure-regualting algorithm can be too sensitive. This may result in surging at a hydrant or in an irrigation system located a long distance away from the pressure sensor. Position 4 of the DIP switch can be used to desensitize the pressure regulation, and in many cases, will reduce or eliminate the surging. If you have a hydrant or an irrigation system some distance from the pressure sensor, don't automatically move switch 4 to OFF. Make sure you have a real issue with surging first.

To recap, positions 1 and 2 are used to tell the controller what pump is in the well, position 3 is used to address nuisance tripping and position 4 may prevent surging at a hydrant. When using SubDrive you will rarely need to change the switch positions. However, with MonoDrive or MonoDriveXT there is a good chance you will, when retrofitting an installation for a pump already downhole. It all adds up to be a product that is simple to install and use, but offers the flexibility you need for a wide variety of applications.

**NOTE:** On some models of the SubDrive family, you will notice another DIP switch, this one is labeled SW2, next to the SW1 SIP switch. SW2 is for future expansion and can be disregarded.

# Addendum - Engine Driven Generators

## Use Of Engine Driven Generators - Single-phase or Three-phase

Table 49 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 49 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 | 5.0 | 2.5 | 3.13 |
| 1.5 | 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 |
| 7.5 | 5.5 | 20 | 25.0 | 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 | 37.50 |
| 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.

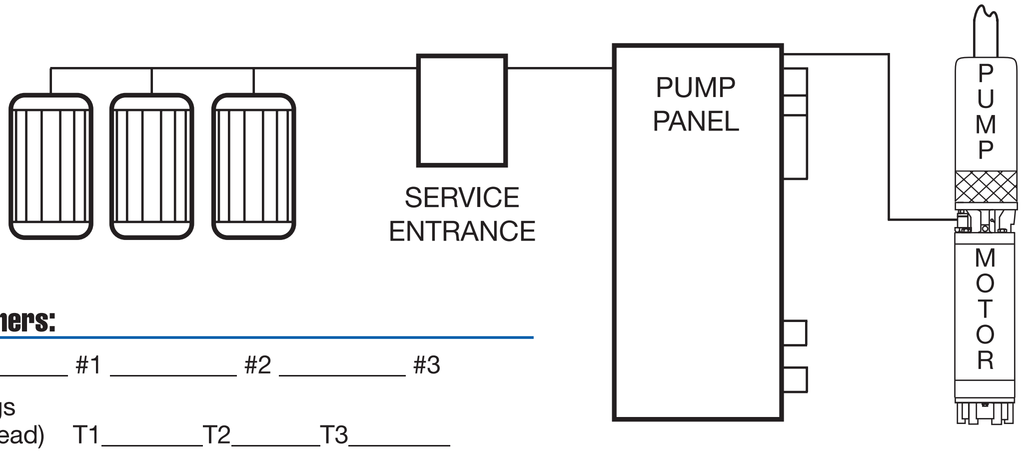
**WARNING:** To prevent accidental electrocution, automatic or manual transfer switches must be used any time a generator is used as standby or back up on power lines. Contact power company for use and approval.

# Submersible Motor Installation Record

## Power Supply:

Cable: Service Entrance to Control ___________m _______ mm²/MCM ❑ Copper ❑ Aluminum ❑ Jacketed ❑ Individual Conductors

Cable: Control to Motor ___________m_______mm²/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 ___________________mm²/MCM
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 Installation Record

RMA No. ____________

INSTALLER'S NAME _________________________

ADDRESS _________________________________

CITY _________________ STATE_____ PC_______

PHONE (___) ____________ FAX (___) ________

CONTACT NAME ____________________________

WELL NAME/ID ____________________________

WATER TEMPERATURE ______________°C

OWNER'S NAME ___________________________________

ADDRESS _______________________________________

CITY ___________________ STATE_____ PC___________

PHONE (___) _______________ FAX (___)_____________

CONTACT NAME ___________________________________

DATE INSTALLED ____________ DATE FAILED__________

## Motor:

Motor No. ____________________ Date Code __________________ KW ________ Voltage ________ Phase ________

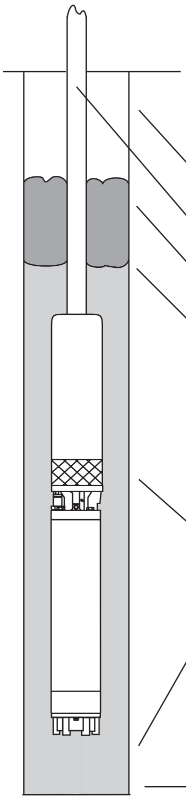
## Pump:

Manufacturer _________________ Model No. _________ Curve No. _________ Rating: _______ l/m@ _______m TDH

NPSH Required ___________ m NPSH Available_________ m Actual Pump Delivery_________l/m@ _________ PSI

Operating Cycle ________________ON (Min./Hr.) __________________ OFF (Min./Hr.) (Circle Min. or Hr. as appropriate)

YOUR NAME ________________________________________________________________ DATE _____/_____/_____



**WELL DATA:**

Total Dynamic Head ________________m

Casing Diameter__________________ mm

Drop Pipe Diameter ________________mm

Static Water Level _________________m

Drawdown (pumping) Water Level_______m

Checkvalves at _________&_________&

_________&_________m

❏ Solid ❏ Drilled

Pump Inlet Setting _________________m

Flow Sleeve: ____No____ Yes, Dia. _____mm

Casing Depth______________________m

❏ Well Screen ❏ Perforated Casing

From_____to_____ft. & _____to_____m

Well Depth_______________________m

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

FORM 2207F

***THIS FORM MUST BE RETURNED FOR ALL FAILURE CLAIMS***

### *SITE INSTALLATION*

**FAR Number** ______________

*Dealer / OEM details* ______________________ *Date* __________

*Contact Name* ______________ *Phone or Email Details* __________ *State* __________

*End User Name* ______________ *End User Location* __________

*New or Old Installation* ______________ *Date Installed* ______________ *Date Failed* ______________

### *PRODUCTS BEING RETURNED FOR ASSESSMENT*

*Pump* ______ *Motor* ________ *Controller (Subdrive/Control Box)* ______________ *Protection unit (Pumptec/plus - Submonitor)* *Other* ________

### *PRODUCT MODEL AND DATE / SERIAL NUMBERS*

*Motor Model* ______________ *Date Code And Serial Number* ______________

*Pump Manufacturer* ______________ *Model Number* ______________

*Pump Condition* ______________ *Duty Flowrate* ______________ *Litres Per Minute*

*Other Components Model* ______________ *Serial Number* ______________

### *POWER SUPPLY AND PROTECTION*

*Mains power (240-415)* __________ *Generator* ______ *KVA* *Overload Setting* ______________ *Amps*

*Overload manufacturer* ______________ *Overload Model / Class* ______________

*Surge / Lightning Protection* ______________ *Model Number* ______________

*Auxiliary Protection* ______________________________

*Drop Cable Insulation Type* ______________ *Size* __________ *mm2* ______ *Length-Metres*

### *MOTOR STARTING METHODS*

*VFD* ______ *Softstarter* ______ *DOL* ______ *Auto Trans* ______ *Ramp up / Change over time* __________ *Sec*

### *PUMP CYCLE TIME / CONTROL*

*Level Probes* ______ *Pressure System* ______ *Manual* ______ *Other* ______________________

### *INSTALLATION DETAILS*

*Bore / River / Tank* ______________ *Bore Materials / Construction (Steel - PVC - Rocl - Sandstone)* ______________

*Bore size* __________ *mm* ______________ ***Screen or Perforations***

*Bore depth* __________ *Metres* *From* __________ *Metres* *To* __________ *Metres*

*Motor depth* __________ *Metres* *Flow Sleeve or Inducer Tube* __________ *Size* __________ *mm*

*Static Water Level* __________ *Metres* *Water Temperature* ______ *C°*

*Pumping WaterLevel* __________ *Metres* *Check Valve(S)Location* ______________

| Description of fault / Additional site information: |
|---|
| |
| |

***IN CASE OF QUESTIONS PLEASE CONTACT FRANKLIN ELECTRIC TEL 1300 372 655 OR EMAIL:feaustralia@fele.com***

# 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 200 megohms without 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 07A18-01-4567)

**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 3.7 KW (5 HP) 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 KW (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 3.7 KW (5 HP) 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 14 & 15. 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 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 13.57 N-m per HP.
- ❑ 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 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.

Form No. 3656 10.03

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______________________________________________________________________________

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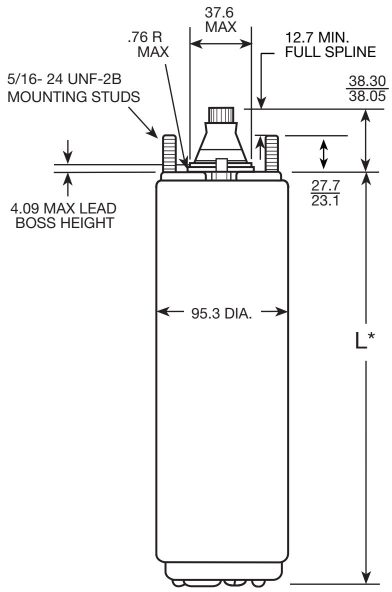
# Notes

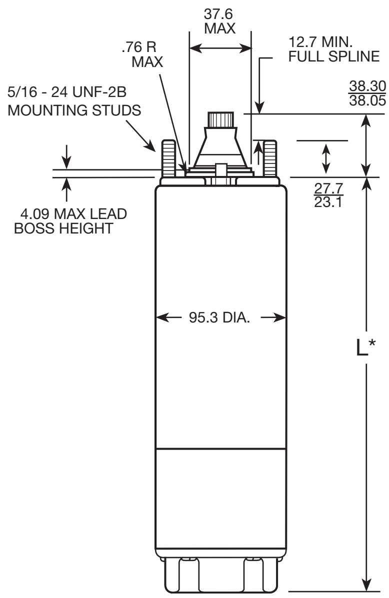
## 4" Super Stainless - Dimensions

(Standard Water Well)



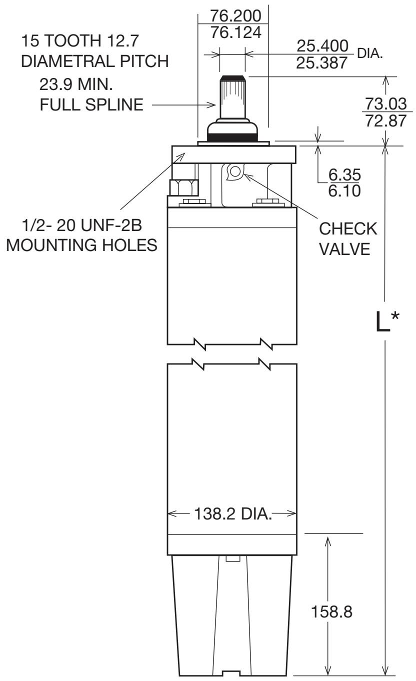

## 4" High Thrust - Dimensions

(Standard Water Well)



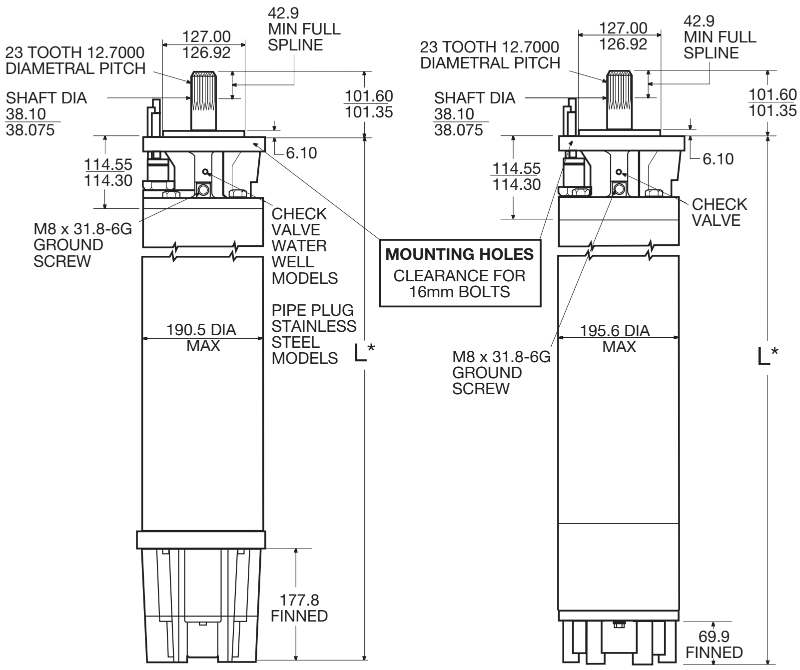

## 6" - Dimensions

(Standard Water Well)




## 8" - Dimensions

(Standard Water Well)




**30 to 75 kW**
**Type 2.1**

**93 to 150 kW**
**Type 1**

Dimensions in mm unless otherwise noted

*** Motor lengths and shipping weights are available on Franklin Electric's web page (www.franklin-electric.com.au) or by calling Franklin on 1300 FRANKLIN.**

# Installation - All Motors

## 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 28**

| Motor | Normal Shaft Height | Dimension Shaft Height | Free End Play | |
|---|---|---|---|---|
| | | | Min. | Max. |
| 4" | 38.1 mm | $\frac{38.30}{38.05}$ mm | .25 mm | 1.14 mm |
| 6" | 73.0 mm | $\frac{73.02}{72.88}$ mm | .75 mm | 1.25 mm |
| 8" Type 1 | 101.5 mm | $\frac{101.60}{101.35}$ mm | .20 mm | .81 mm |
| 8" Type 2.1 | 101.5 mm | $\frac{101.60}{101.35}$ mm | .75 mm | 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.

## Diaphragm Position Measurement

**TABLE 28A Measure from Diaphragm Cover to Diaphragm via hole at base of motor**

| Size | Motor Type | Diaphragm Measurement | |
|---|---|---|---|
| | | Min | Max |
| 4" | Super Stainless | n/a | n/a |
| 4" | High Thrust, Cast Thrust Housing | 14mm | 18mm |
| 4" | High Thrust, Straight (Clad) Thrust Housing | 8mm | 12mm |
| 6" | Straight Thrust Housing | 31mm | 38mm |
| 6" | Tapered Thrust Housing | 57mm | 61mm |
| 6" | Hi Temp 50C and 90C | 46mm | 48mm |
| 6" | Straight (Clad) Thrust Housing | 17mm | 21mm |
| 8" | Type 1, Straight Thrust Housing | 33mm | 43mm |
| 8" | Type 2 and 2.1, Tapered Thrust Housing | 32mm | 38mm |
| 8" | Hi Temp 75C | 33mm | 43mm |

## 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.

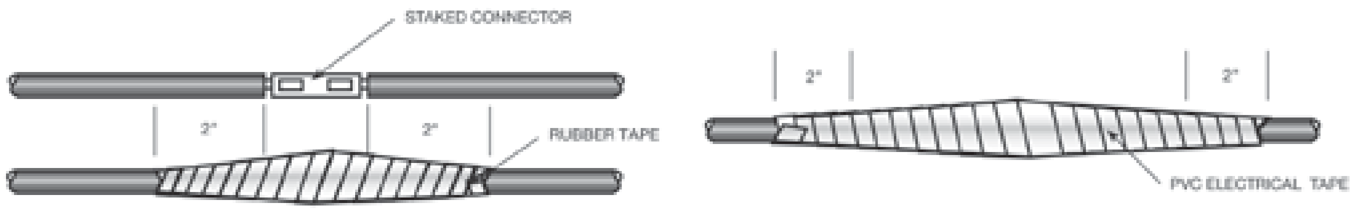



FIG. 12

## 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.**

## Tightening Motor Lead Connector Jam Nut

**4" Motors:**
20 to 27 N-m (15 to 20 ft-lb.)

**6" Motors:**
68 to 81 N-m (50 to 60 ft-lb.)

**8" Motors with 1-3/16" to 1-5/8" Jam Nut:**
68 to 81 N-m (50 to 60 ft-lb.)

**8" Motors with 4 Screw Clamp Plate:**
Apply increasing torque to the screws equally in a criss-cross pattern until 9.0 to 10.2 N-m (80 to 90 in-lb.) is reached.

Jam nut tightening torques recommended for held assembly are shown. Rubber compression set within the first few hours after assembly may reduce the jam nut torque. This is a normal condition which does not indicate reduced seal effectiveness. Retightening is not required, but is permissible and recommended if original torque was questionable.

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.**

# Maintenance - All Motors

## System Troubleshooting

### 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 34-35. | 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 32-34. | Repair or replace. |

### Motor Starts Too Often

| Possible Cause | Checking Procedures | Corrective Action |
|---|---|---|
| **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 Troubleshooting

### 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 34-35 for single-phase. | Repair or replace. |

### Motor Runs But Overload Protector Trips

| Possible Cause | Checking Procedures | Corrective Action |
|---|---|---|
| **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 34-35. | Repair or replace. |
| **D.** Defective motor or cable. | For detailed procedures, see pages 32-34. | Repair or replace. |
| **E.** Worn pump or motor. | Check running current, See pages 13, 15 & 16. | Replace pump and/or motor. |

# Maintenance - All Motors

**TABLE 32 Preliminary Tests - All sizes SIngle and Three-Phase**

| Test | Procedure | What it Means |
|---|---|---|
| **Insulation Resistance** | 1. Open master breaker and dissconnect all lead from control box or pressure swich (QD type control, remove lid) to avoid electric shock hazard and damage to the meter.<br>2. Set the scale meter 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 33), 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 restistance 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-phrase motorsmeasure the resistance line to line for all three combinations. | 1. If all ohms values are normal (Tables 13, 16 & 17), 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 value is greater than normal and some less on single-phase motors, the leads are mixed. See Page 34 to verify cable colors. |

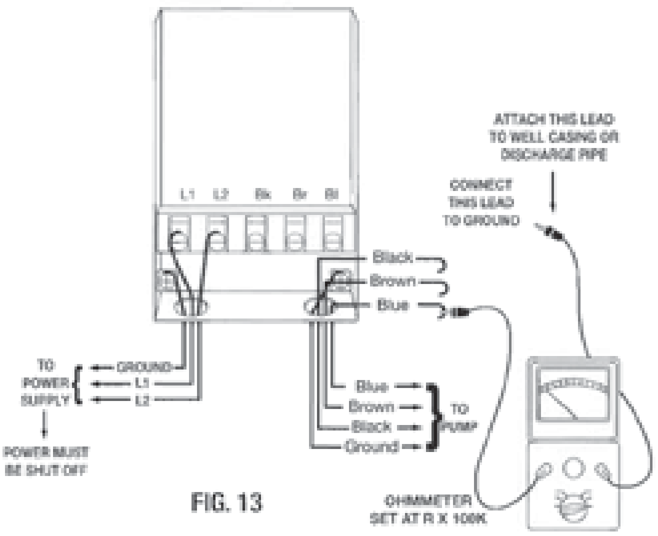



FIG. 13

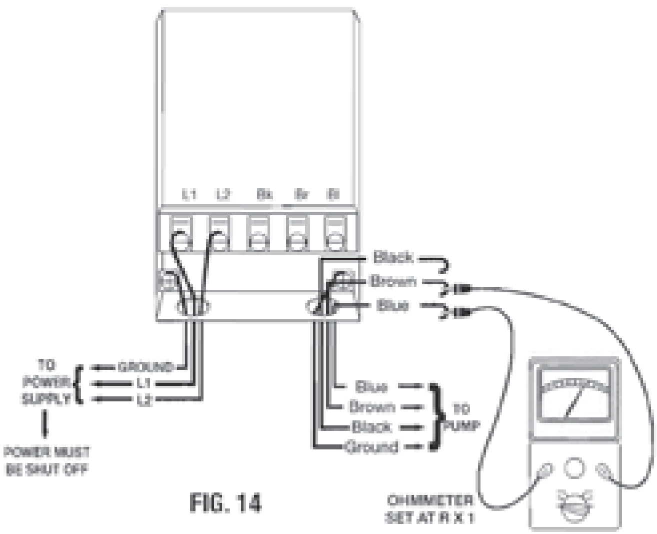



FIG. 14

| | 3 Wire | | | PSC |
|---|---|---|---|---|
| | AUST | EUR | USA | EUR |
| **Main / Run Winding** | Blue | Blue/Grey | Black | Blue/Grey |
| **Start / Aux Winding** | White | Black | Red | Brown |
| **Common** | Red | Brown | Yellow | Black |

## Insulation Resistance Readings

**TABLE 33 Normal Ohm and Megohm Valves Between All Leads and Ground**

| Condition of Motor and Leads | Ohms Value | MEGOHM Value |
|---|---|---|
| A new motor ( without drop cable ). | 200,000,000 ( or more ) | 200 ( 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 ) | 2.0 ( or more ) |
| Motor in good condition. | 1,000,000 - 2,000,000 | 1.0 |
| Insulation damage, locate and repair | Less than 1,000,000 | Less than 1.0 |

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

Table 33 is based on readings taken with a megohm meter with a 500VDC 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

The winding resistance measured at the motor should fall within the values in tables 13, 16, & 17. When measured through the drop cable, the resistance of the drop cable must be subtracted from the ohmmeter readings to get the winding resistance of the motor. See table below.

### Drop Cable Resistance

**DC Resistance in Ohms per 100 meters of wire (two conductors) @ 10°C**

| Square millimeter (Copper) | 1.5 | 2.5 | 4 | 6 | 10 | 16 |
|---|---|---|---|---|---|---|
| Ohms | 2.630 | 1.576 | 0.977 | 0.651 | 0.374 | 0.238 |

| 25 | 35 | 50 | 70 | 95 | 120 | 150 | 185 | 240 |
|---|---|---|---|---|---|---|---|---|
| 0.153 | 0.108 | 0.075 | 0.053 | 0.040 | 0.031 | 0.025 | 0.021 | 0.016 |

## Indication Of Cables When Color Code Is Unknown (Single-Phase 3-Wire Units)

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

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 brown lead.

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

Highest is the BLACK lead
Lowest is the BLUE 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 readings (6 ohms) was

Cable 3–Brown

From the yellow lead, the highest reading (4 ohms) was

To Cable 1–Black

From the yellow lead, the lowest reading (2 ohms) was

To Cable 2–Blue

| | 3 Wire | | | PSC |
|---|---|---|---|---|
| | AUST | EUR | USA | EUR |
| Main / Run Winding | Blue | Blue/Grey | Black | Blue/Grey |
| Start / Aux Winding | White | Black | Red | Brown |
| Common | Red | Brown | Yellow | 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 the 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 Black lead should momentarily be high, then drop within one second to values on Page 13. This verifies relay operation. Current in Blue and Brown leads should not exceed values on Page 13.
3. Relay failures will cause black lead current to remain high and overload tripping.
4. Open run capacitor(s) will cause amps to be higher than normal in the blue an brown motor leads and lower than normal in the black motor lead.
5. A bound pump will cause locked rotor amps and overload tripping.
6. Low amps may be caused by pump running at shutoff, worn pump, or stripped splines.
7. Failed start capacitor or open 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, and relays 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 relays, refer to operational test procedure described above in Section B-2.

## Ohmmeter Tests

**QD Control Box (Power Off)**

**A. START CAPACITOR**

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. POTENTIAL (VOLTAGE) RELAY**

**Step 1. Coil Test**

1. Meter setting: R x 1,000.
2. Connections: #2 & #5.
3. Correct meter readings:

   For 220-240 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.

## 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.

**CAUTION: The tests in this manual for components such as capacitors, and relays 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 relays, refer to operational test procedure described on Page 34, Section B-2.**

## QD Control Box Parts List

**TABLE 36 Q.D. Control Box Components 50Hz.**

| Model | KW | HP | Volts | Relay | Capacitor | Capacitor Rating | Capacitor-Overload Asm. | Overload |
|---|---|---|---|---|---|---|---|---|
| 2803730119 | 0.25 | 1/3 | 230 | 155031112 | 275461123 | 43-53 Mfd. 220v | 151033957 | 155250101 |
| 2803730119 | 0.37 | 1/2 | 230 | 155031112 | 275461123 | 43-53 Mfd. 220v | 151033957 | 155250101 |
| 2803730119 | 0.55 | 3/4 | 230 | 155031112 | 275461108 | 59-71 Mfd. 220v | 151033906 | 155250102 |
| 2803730119 | 0.75 | 1 | 230 | 155031112 | 275461106 | 86-103 Mfd. 220v | 151033918 | 155250103 |

Same parts are used on Suffix 119 Control Boxes.

The replacement kit for relay 155031112 is 305213912.

### Capacitor Replacement Kit

| Capacitor | Kit |
|---|---|
| 275461106 | 305205906 |
| 275461108 | 305205908 |
| 275461123 | 305205923 |

### Cap/Overload asm. replacement kit

| Assembly | Kit |
|---|---|
| 151033906 | 305218906 |
| 151033918 | 305218918 |
| 151033957 | 305218957 |

## Integral HP Control Box Parts List

**TABLE 36A Control Box Components, 1.1 KW and larger 50Hz.**

| Model | KW | HP | Volts | Relay (1) | Start | Run | Overloads |
|---|---|---|---|---|---|---|---|
| 2823608119 | 1.1 | 1 1/2 | 230 | 155031112 | One 275464113<br>105-126 Mfd. 220v | One 155328102<br>10 Mfd. 370v | 275411114 |
| 2823618119 | 1.5 | 2 | 230 | 155031112 | One 275468115<br>189-227 Mfd. 220v | One 155328103<br>20 Mfd. 370v | 275411102 run,<br>275411106 start |
| 2823528110 | 2.2 | 3 | 230 | 155031112 | One 275468119<br>270-324 Mfd. 220v | One 155327102<br>35 Mfd. 370v | 275406107 run,<br>275411107 start |
| 2822539010 | 3.7 | 5 | 230 | 155031112 | Two 275468115<br>189-227 Mfd. 220v | One 155327101<br>30 Mfd. 220v<br>One 155327109<br>45 Mfd. 220v | 275406102 run,<br>275411102 start |

(1) Relay Replacement Kit 305213912

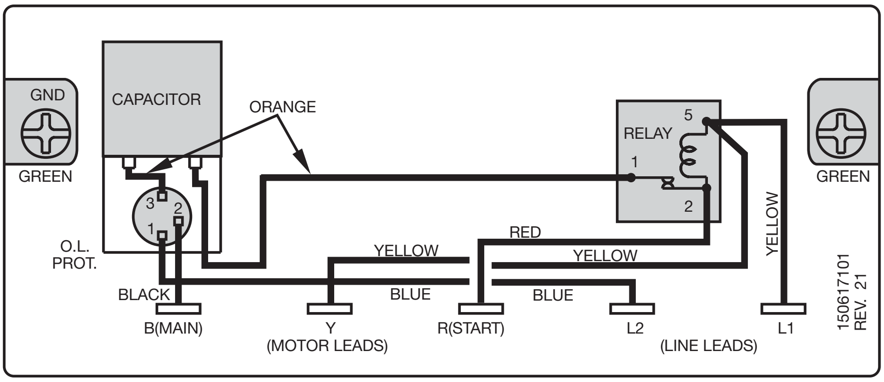
### Capacitor Replacement Kit

| Capacitor | Kit |
|---|---|
| 155327101 | 305203901 |
| 155327102 | 305203902 |
| 155327109 | 305203909 |
| 155328102 | 305204902 |
| 275464113 | 305207913 |
| 275468115 | 305208915 |
| 275468119 | 305208919 |

### Overload Replacement Kit

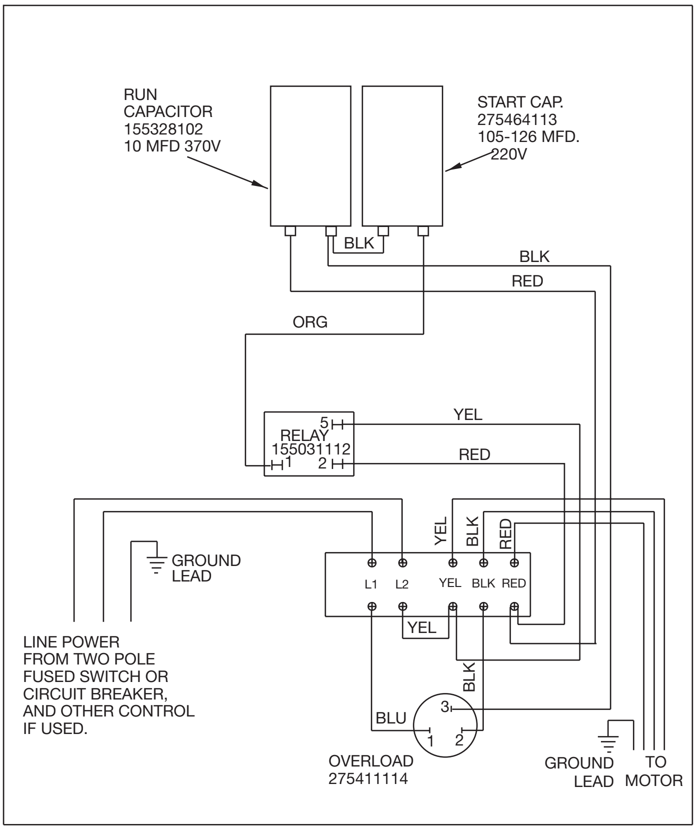
| Capacitor | Kit |
|---|---|
| 275406102 | 305214902 |
| 275406107 | 305214907 |
| 275411102 | 305215902 |
| 275411106 | 305215906 |
| 275411107 | 305215907 |
| 275411114 | 305215914 |

## Control Box Wiring Diagrams

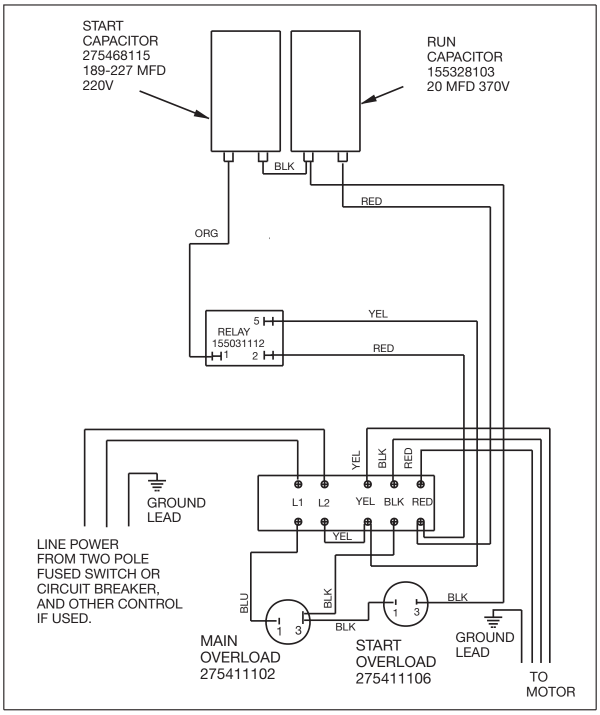



**0.25 – 0.75kW**
**1/3 – 1 HP 4”**
280 373 0119

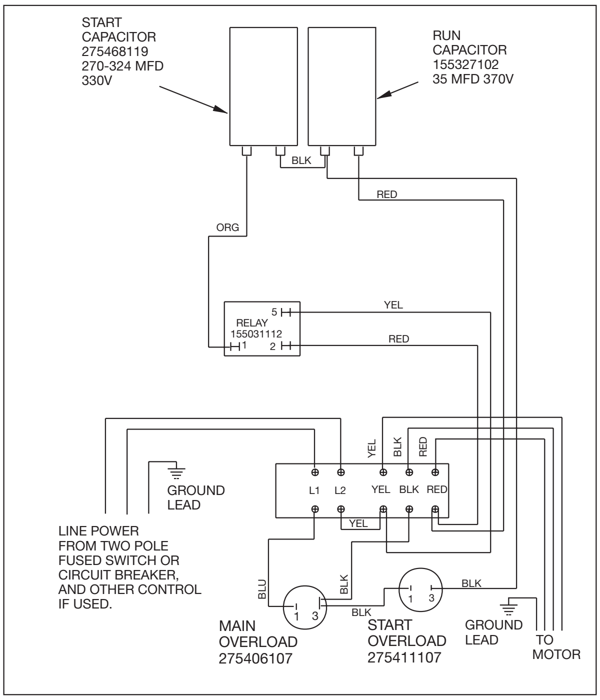
| | 3 Wire | | | PSC |
|---|---|---|---|---|
| | AUST | EUR | USA | EUR |
| **Main / Run Winding** | Blue | Blue/Grey | Black | Blue/Grey |
| **Start / Aux Winding** | White | Black | Red | Brown |
| **Common** | Red | Brown | Yellow | Black |



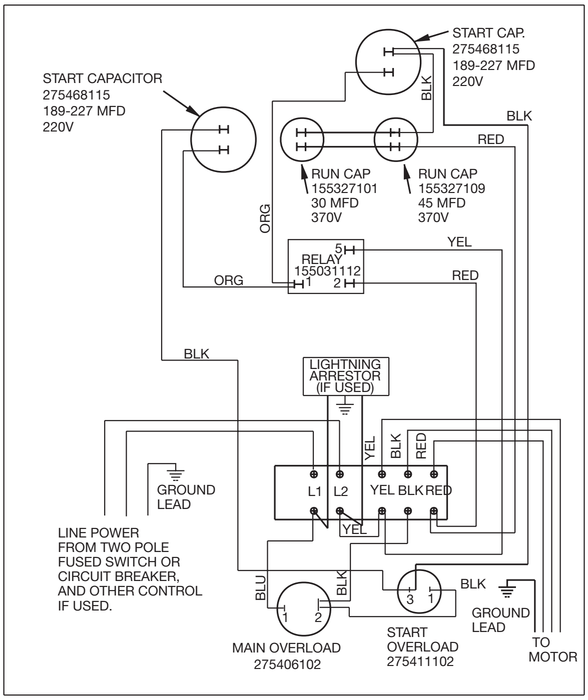

**1.1kW**
**1 1/2 HP**
282 360 8119




**1.5kW**
**2 HP**
282 361 8119




**2.2kW**
**3 HP**
282 362 8110




**3.7kW**
**5 HP**
282 363 9010

## Pumptec-IR

### Pumptec - IR - Troubleshooting After Installation

| SYMPTOM | POSSIBLE CAUSES | 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 Yellow Light With Slight Flicker** | Duty - Site Related | Rapidly Changing Load - 25% within 20 Sec |
| **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** | 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 2-wire motors. Try to reduce water splashing or use a different switch. |

## Pumptec-Plus

Pumptec-Plus is a pump/motor protection device designed to work on any 220V 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 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 242 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 50 Hz. |
| **Solid Red Light** | Low Line Voltage | The line voltage is below 198 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 198 volts for more than 2.5 seconds. Undervoltage trips will also occur if the line frequency rises too far above 50 Hz. |

## Pumptec-Plus

### Pumptec-Plus - Troubleshooting 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 198 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 242 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. |

## SubDrive2W, 75, 100, 150, 300, MonoDrive, & MonoDrive XT
### SubDrive/MonoDrive Troubleshooting

| NUMBER OF FLASHES OR DIGITAL DISPLAY | FAULT | POSSIBLE CAUSE | CORRECTIVE ACTION |
|---|---|---|---|
| **1** | MOTOR UNDERLOAD | Overpumped well<br>Broken shaft or coupling<br>Blocked screen, worn pump<br>Air/gas locked pump<br>SubDrive not set properly for pump end | Frequency near maximum with less than 65% of expected load, 42% if DIP Switch # 3 is “ON”<br>System is drawing down to pump inlet (out of water)<br>High static, light loading pump - reset DIP switch #3 to “ON” for less Underload Sensitivity if not out of water<br>Check pump rotation (SubDrive only) reconnect if necessary for proper rotation<br>Air/gas locked pump - if possible, set deeper in well to reduce<br>Verify DIP switches are set properly |
| **2** | UNDERVOLTAGE | Low line voltage<br>Misconnected input leads | Line voltage low, less than approximately 150 VAC (normal operating range = 190 to 260 VAC)<br>Check incoming power connections and correct or tighten if necessary<br>Correct incoming voltage - check circuit breaker or fuses, contact power company |
| **3** | LOCKED PUMP | Motor and/or pump misalignment<br>Dragging motor and/or pump<br>Abrasives in pump | Amperage above SFL at 10 Hz<br>Remove and repair or replace as required |
| **4**<br>(MonoDrive & MonoDriveXT only) | INCORRECTLY WIRED | - MonoDrive only<br>- Wrong resistance values on main and start | Wrong resistance on DC test at start<br>Check wiring, check motor size and DIP switch setting, adjust or repair as needed |
| **5** | OPEN CIRCUIT | Loose connection<br>Defective motor or drop cable<br>Wrong motor | Open reading on DC test at start.<br>Check drop cable and motor resistance, tighten output connections, repair or replace as necessary, use “dry” motor to check drive functions, if drive will not run and exhibits underload fault replace drive |
| **6** | SHORT CIRCUIT | When fault is indicated immediately after power-up, short circuit due to loose connection, defective cable, splice or motor | Amperage exceeded 50 amps on DC test at start or max amps during running<br>Incorrect output wiring, phase to phase short, phase to ground short in wiring or motor<br>If fault is present after resetting and removing motor leads, replace drive |
| | OVER CURRENT | When fault is indicated while motor is running, over current due to loose debris trapped in pump | Check pump |
| **7** | OVERHEATED DRIVE | High ambient temperature<br>Direct sunlight<br>Obstruction of airflow | Drive heat sink has exceeded max rated temperature, needs to drop below 85 °C to restart<br>Fan blocked or inoperable, ambient above 125 °F, direct sunlight, air flow blocked<br>Replace fan or relocate drive as necessary |
| **8**<br>(SubDrive300 only) | OVER PRESSURE | Improper pre-charge<br>Valve closing too fast<br>Pressure setting too close to relief valve rating | Reset the pre-charge pressure to 70% of sensor setting. Reduce pressure setting well below relief valve rating. Use next size larger pressure tank.<br>Verify valve operation is within manufacturer’s specifications.<br>Reduce system pressure setting to a value less than pressure relief rating. |
| **RAPID** | INTERNAL FAULT | A fault was found internal to drive | Unit may require replacement. Contact your supplier. |
| **9**<br>(SubDrive 2W Only) | OVER RANGE<br>(Values outside normal operating range) | Wrong hp/voltage<br>Internal fault | Verify motor hp and voltage<br>Unit may require replacement. Contact your supplier. |

**WARNING:** Serious or fatal electrical shock may result from failure to connect the motor, SubDrive/MonoDrive 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

## Pumptec

Pumptec is a load sensing device that monitors the load on submersible pump/motors. If the load drops below a preset level for a minimum of 4 seconds the Pumptec will shut off the motor.

The Pumptec is designed for use on Franklin Electric 2- and 3-wire motors (.25 to 1.1kW) 220V. The Pumptec is not designed for Jet Pumps.

| Symptom | Checks or Solution |
|---|---|
| **Pumptec trips in about 4 sec. 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 Pumptec wired correctly? Check the wiring diagram and pay special attention to the positioning of the power lead. |
| **Pumptec trips in about 4 sec. 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). |
| **Pumptec will not time-out and reset.** | A. Check switch position on the side of the circuit board in Pumptec. Make sure the switch is not set between settings.<br>B. If the reset time switch is set to manual reset (position 0), 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. Bypass Pumptec by connecting L2 and the motor lead with a jumper. If motor does not run, the problem is not Pumptec.<br>D. Check that Pumptec is installed between the control switch and motor. |
| **Pumptec will not trip when the pump breaks suction.** | A. Be sure you have a Franklin motor.<br>B. Check wiring connections. Is power lead connected to the 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 Pumptec from tripping. It may be necessary to adjust Pumptec for these extreme applications. Call Franklin Electric on 1300 FRANKLIN for information.<br>E. Does the control box have a run capacitor? If so, Pumptec will not trip (except with Franklin 1.1kW motors). |
| **Pumptec chatters when running.** | A. Check for low voltage.<br>B. Check for water logged tank. Rapid cycling for any reason can cause the Pumptec relay to chatter.<br>C. Make sure the L2 and motor wires are installed correctly. If they are reversed, the unit can chatter. |

## Subtrol-Plus - Obsolete ( Refer to SubMonitor section )

### Subtrol-Plus -Troubleshooting 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.<br>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 - Obsolete ( Refer to SubMonitor section )

**Subtrol-Plus -Troubleshooting 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>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. |

## SubMonitor

### SubMonitor Troubleshooting

| FAULT MESSAGE | PROBLEM/CONDITION | POSSIBLE CAUSE |
|---|---|---|
| **SF Amps Set Too High** | SF Amps setting above 359 Amps. | Motor SF Amps not entered. |
| **Phase Reversal** | Reversed incoming voltage phase sequence. | Incoming power problem. |
| **Underload** | Normal line current. | Wrong SF Max Amps setting. |
| | Low line current. | Over pumping well.<br>Clogged pump intake.<br>Closed valve.<br>Loose pump impeller.<br>Broken shaft or coupling.<br>Phase loss. |
| **Overload** | Normal line current. | Wrong SF Max Amps setting. |
| | High line current. | High or low line voltage.<br>Ground fault.<br>Pump or motor dragging.<br>Motor stalled or bound pump. |
| **Overheat** | Motor temperature sensor has detected excess motor temperature. | High or low line voltage.<br>Motor is overloaded.<br>Excessive current unbalance.<br>Poor motor cooling.<br>High water temperature.<br>Excessive electrical noise (VFD in close proximity). |
| **Unbalance** | Current difference between any two legs exceeds programmed setting. | Phase loss.<br>Unbalanced power supply.<br>Open delta transformer. |
| **Overvoltage** | Line voltage exceeds programmed setting. | Unstable power supply. |
| **Undervoltage** | Line voltage below programmed setting. | Poor connection in motor power circuit.<br>Unstable or weak power supply. |
| **False Starts** | Power has been interrupted too many times in a 10 second period. | Chattering contacts.<br>Loose connections in motor power circuit.<br>Arcing contacts. |

# Abbreviations

| | |
|---|---|
| A | Amp or amperage |
| AWG | American Wire Gauge |
| BJT | Bipolar Junction Transistor |
| °C | Degree Celsius |
| CB | Control Box |
| CRC | Capacitor Run Control |
| DI | Deionized |
| Dv/dt | Rise Time of the Voltage |
| EFF | Efficiency |
| °F | Degree Fahrenheit |
| FDA | Federal Drug Administration |
| FL | Full Load |
| ft | Foot |
| ft-lb | Foot Pound |
| ft/s | Feet per Second |
| GFCI | Ground Fault Circuit Interrupter |
| gpm | Gallon per Minute |
| HERO | High Efficiency Reverse Osmosis |
| hp | Horsepower |
| Hz | Hertz |
| ID | Inside Diameter |
| IGBT | Insulated Gate Bipolar Transistor |
| in | Inch |
| kVA | Kilovolt Amp |
| kVAR | Kilovolt Amp Rating |
| kW | Kilowatt (1000 watts) |
| L1, L2, L3 | Line One, Line Two, Line Three |
| lb-ft | Pound Feet |
| L/min | Litre per Minute |
| mA | Milliamp |
| max | Maximum |
| MCM | Thousand Circular Mils |
| mm | Millimetre |
| MOV | Metal Oxide Varister |
| NEC | National Electrical Code |
| NEMA | National Electrical Manufacturer Association |
| Nm | Newton Metre |
| NPSH | Net Positive Suction Head |
| OD | Outside Diameter |
| OL | Overload |
| PF | Power Factor |
| psi | Pounds per Square Inch |
| PWM | Pulse Width Modulation |
| QD | Quick Disconnect |
| R | Resistance |
| RMA | Return Material Authorization |
| RMS | Root Mean Squared |
| rpm | Revolutions per Minute |
| SF | Service Factor |
| SFhp | Service Factor Horsepower |
| S/N | Serial Number |
| TDH | Total Dynamic Head |
| UNF | Fine Thread |
| V | Voltage |
| VAC | Voltage Alternating Current |
| VDC | Voltage Direct Current |
| VFD | Variable Frequency Drive |
| W | Watts |
| XFMR | Transformer |
| Y-D | Wye-Delta |
| Ω | ohms |

System Solutions

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**TOLL FREE HELP FROM A FRIEND**

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

**www.franklin-electric.com.au**

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