50 Hz Submersible Motors

Application ■ Installation ■ Maintenance

Single and Three Phase Motors

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South African Edition

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

Application – All Motors

Storage

Franklin Electric submersible motors are based on 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 1 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 up-thrust bearing. This is an acceptable operation for short periods at each start, but running continuously with

up-thrust may cause excessive wear on the up-thrust 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 & 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 the voltage supplied to the motor.

Table 4 references the motor kilowatt rating, single-phase and three-phase, total effective KVA required.

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

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.

Table 2 Transformer Capacity

Motor Rating		Total Effective KVA Required
HP	kW	
1.5	**1.1**	3
2	**1.5**	4
3	**2.2**	5
4	**3.0**	
5	**3.7**	7.5
5.3	**4.0**	
7.5	**5.5**	10
10	**7.5**	15
12.4	**9.3**	
15	**11**	20
20	**15**	25
25	**18.5**	30
30	**22**	40
40	**30**	50
50	**37**	60
60	**45**	75
75	**55**	90
90	**67**	
100	**75**	120
110	**83**	
125	**90**	150
150	**110**	175
175	**130**	200
200	**150**	230
250	**185**	

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.

Table 3 Torque required (Example)

Motor Rating		HP x 13.57 N-m	Minimum Safe Torque Load
HP	kW		
1HP & Less	.75kW	1 x 13.57	13.57 Nm
20HP	15kW	20 x 13.57	271.4 Nm
75HP	55kW	75 x 13.57	1017.8 Nm
200HP	150kW	150 x 13.57	2714 Nm

To safely withstand maximum unscrewing torques with a minimum safety factor of 1.5, tightening all threaded joints to at least 13.57 Nm 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.

Engine Driven Generators

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

Use of Check Valves (Non Return 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 meters of the pump and below the draw down level of the water supply. For deeper settings, it is recommended that line check valves be installed per the manufacturer's recommendations.

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

Check valves are used to hold pressure in the system when the pump stops. They also prevent backspin, water hammer and up-thrust. 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 up-thrust and water hammer problems.

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

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

Water Hammer - If the lowest check valve is more than 9.0 meters above the standing water level, or a lower check valve leaks and the check valve above holds a partial vacuum is created in the discharge piping. On the next pump start, water moving at very high velocity fills the void and strikes the closed check valve and the

stationary water in the pipe above it, causing a hydraulic shock. This shock can split pipes, break joints and damage the pump and/or motor. Water hammer is an easily detected noise. When discovered, the system should be shut down and the pump installer contacted to correct the problem.

Wells – Large Diameter, Uncased, Top Feeding & Screened Sections

Franklin Electric submersible motors are designed to operate with a cooling flow of water over the motor.
If the pump installation does not provide the minimum flow shown in Table 6, a flow inducer sleeve (flow sleeve) must be used. The conditions requiring a flow sleeve are:

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

Water Temperature and Flow

Franklin Electric submersible motors, except 8" SEVERE DUTY (see note below), are designed to operate up to full load horsepower in water up to 30℃. A flow of 7.62 cm/sec for 4" High Thrust motors 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℃, water flow past the motor must be increased to maintain safe motor operating temperatures. See HOT WATER APPLICATIONS on Page 7.

NOTE: 8" SEVERE DUTY motors are designed to operate with loading up to full load horsepower in water up to 90℃ with water flow past motor of 0.15 m/sec.

Table 4 Required Cooling Flow

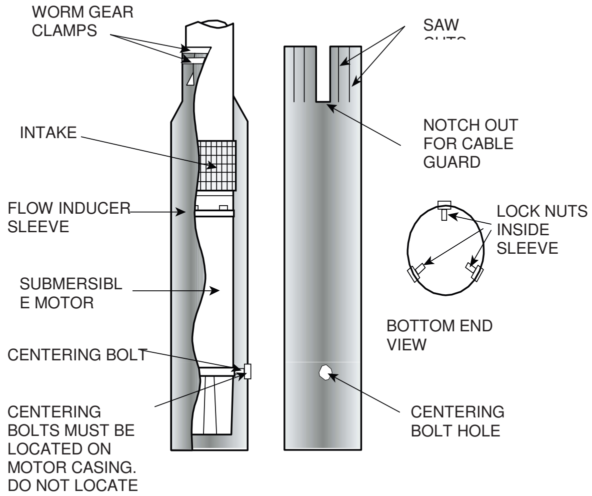
Minimum l/m required for motor cooling in water up to 30℃			
Casing or Sleeve ID (mm)	**4" High Thrust Motor 7.62 cm/sec. l/m**	**6" Motor 15.24cm/sec l/m**	**8" Motor 15.24cm/sec l/m**
102	4.5	-	-
127	26.5	-	-
152	49	34	-
178	76	95	-
203	114	170	40
254	189	340	210
305	303	530	420
356	416	760	645
406	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 a 203 mm or smaller flow sleeve provides the required cooling.



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 5 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	203	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

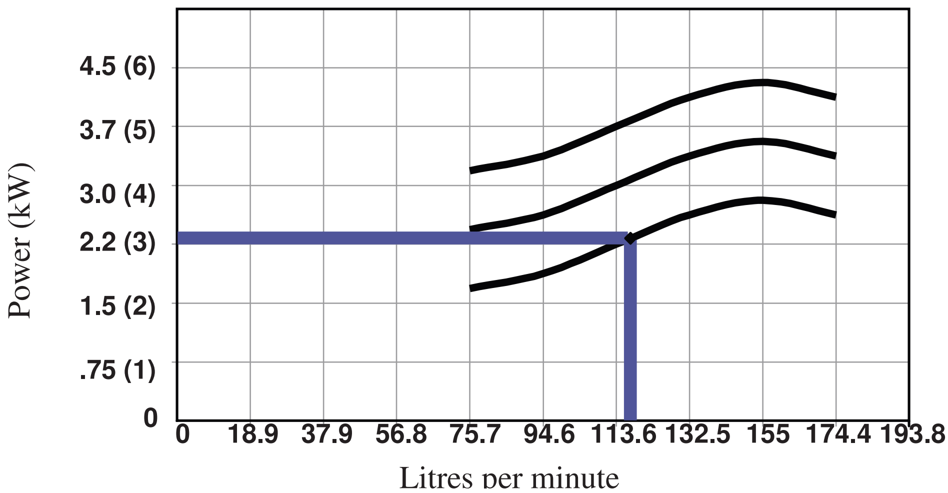
When the pump-motor operates in water hotter than 30℃, a flow rate of at least .91 m/sec is required. When selecting the motor to drive a pump in over 30℃ water, the motor horsepower must be de-rated per the following procedure.

1. Using Table 6, 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 6 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. See Figure 2



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 7 Heat Factor Multiplier at .91 m/sec Flow Rate

Maximum Water Temperature	1/3 – 5 HP .25 – 3.7 kW	7 ½ - 30 HP 5.5 – 22 kW	Over 30 HP Over 22 kW
60℃	1.25	1.62	2.00
55℃	1.11	1.32	1.62
50℃	1.00	1.14	1.32
45℃	1.00	1.00	1.14
40℃	1.00	1.00	1.00
35℃	1.00	1.00	1.00

Hot Water Application - Example

EXAMPLE: A 6" pump end requiring 29.1 kW (39 HP) input will pump 51℃ 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℃. 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℃.

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

Drawdown Seals

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

Grounding Control Boxes & Panels

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

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 & Panel Environment

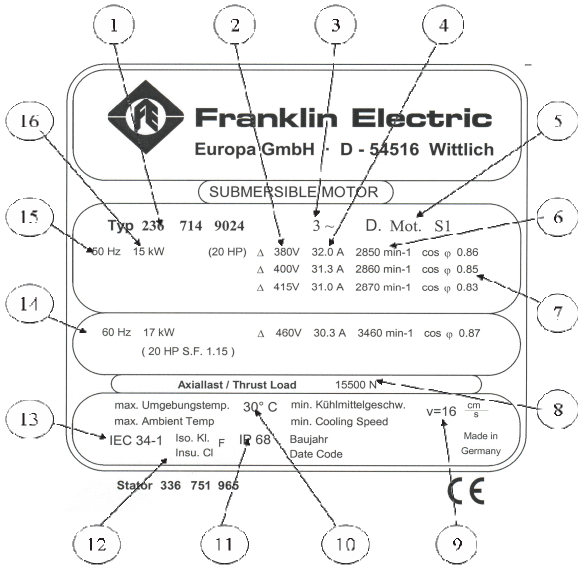
Franklin Electric control boxes are designated IP 23. They are suitable for indoor and outdoor applications within temperatures of -10℃ to 50℃. Operating control boxes below -10℃ can cause reduced starting torque and loss of overload protection when overloads are located in control boxes.

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.

Motor Electrical & Mechanical Specifications

The ***nameplate*** on any electrical motor contains important information. Bear in mind that leaflets and brochures may change but the nameplate MAY NOT be out of date. When in doubt, use the nameplate values. A typical Franklin motor has the following nameplate etched onto the motor side towards the top:



Nameplate Specifications	
Legend number	**Description**
1	Unique model number, identifying motor
2	Design voltage that indicates required voltage to operate motor within specifications. (230V is single phase and 400V, 525V is three phase)
3	Number of phases required from voltage supply. 1~ indicates single phase and 3 ~ indicates three phase
4	Typical current demanded by the motor to supply the load. Three typical load currents for three different supply voltages are indicated – all at full load
5	Motor starting torque and starting current classification
6	Motor shaft speed under full load conditions
7	Power factor of the motor under full load
8	Thrust load carrying capability
9	Required cooling flow past the motor. This specification makes ir necessary to consider the use of a flow inducing sleeve under certain operating conditions
10	Maximum operating water temperature
11	Motor sealing classification
12	Motor winding classification
13	Specification and standard to which the motor and motor design complies
14	Operational characteristics at 60 Hz
15	Required operating frequency for specifications discussed
16	Motor shaft power rating

Application – Single Phase Motors

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..

Single-phase Cable (Service Entrance to Motor – Maximum Length in Meters)

Cable for submersible motors must be suitable for sub- merged 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 accept-able starting voltage and cable temperature.

Minimum Square Millimeter 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℃). Individual conductor is based on Table 52-B2, Installation Method G using Column 6 In Table 52-C10 (70℃).

The table 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 3-phase controller should not exceed 25% of table maximum length to assure reliable starter operation.

Single Phase Cable Selection Chart

Table 8 Single Phase Maximum Length of Copper Cable (meters)

Motor Rating			Metric Cable Size – 70 ℃ Insulation – Copper Wire – Square Millimeters									
Volts	kW	HP	2.5	4	6	10	16	25	35	50	70	95
230 Volt	.25	1/3	280	450	670	1130	1750	2640	3590	4940	6560	8110
	.37	½	200	320	480	810	1260	1900	2590	3580	4770	5920
	.55	¾	130	220	320	550	850	1290	1760	2430	3230	4000
	.75	1.0	100	170	250	430	670	1010	1380	1910	2550	3160
	1.1	1.5	70	120	180	300	470	710	980	1360	1850	2320
50 Hz	1.5	2.0	60	90	130	230	360	550	760	1060	1440	1820
	2.2	3.0	0	60	90	150	230	350	490	680	920	1160

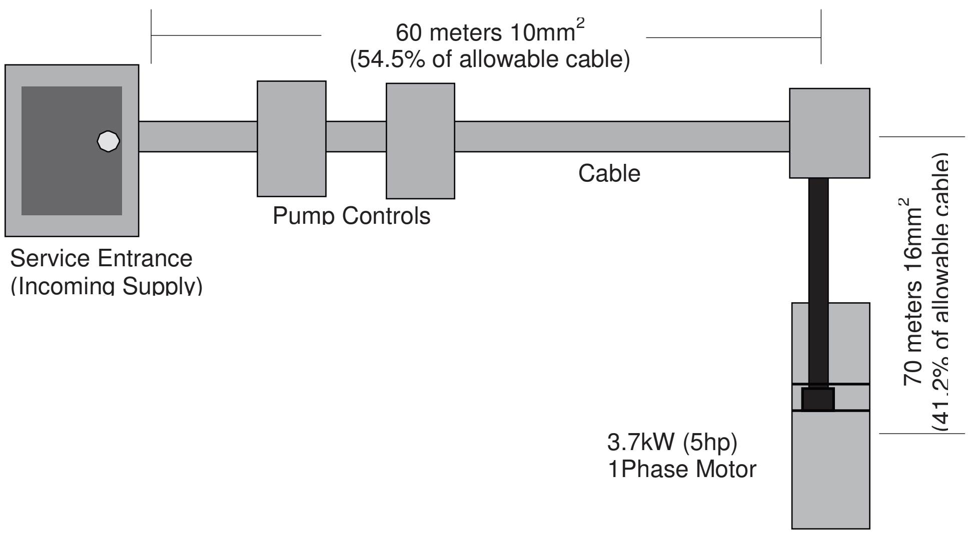
Two different cable sizes can be used.

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

For example, in a replacement installation, the well already has 60 meters of buried 6 mm^2 cable between the service entrance and the wellhead. The question is: What size cable is required in the well with a 2.2 kW, 230 volt, single phase motor setting at 70 meters?

1. From Table 8, a 2.2kW motor can use up to 90 meters of 6 mm^2 cable.
2. The application has 60 meters of buried 6 mm^2 cable.
3. 60 meters ÷ 90 meters (max allowable) is equal to 66.66% of max allowable.
4. 100% - 66.66% = 33.34% remaining of another size cable.
5. 70 meters (top of borehole to motor) is 33.34% of max allowable length of another cable size.
6. 70 meters ÷ 0.333 (33.34%) = 210 meters is maximum allowable.
7. 210 meters is less than or equal to what size cable in Table 8, under the 2.2 kW listing?
8. The table shows 10 mm^2 is good for 150 meters, which is too short. 16 mm^2 is good for 230 meters, therefore 16 mm^2 can be used for the remaining 70 meters.

EXAMPLE 3.7 kW (5 HP), 220 Volt, Single Phase Motor



Single phase motor performance data

Table 9 Single Phase 3-wire Standard Performance Data (50 Hz)

Type	Motor Model Prefix	Nameplate Rating					Full Load Watts	Winding Resistance		Efficiency % at % load			Cos φ at % load			Locked Rotor Amps	Circuit Breaker	
		kW	HP	Volts	Line Volts	Amps		Main	Start	50	75	100	50	75	100		STD.r	Delay
4 Inch Cap Start	214563	0,25	1/3	230	230	2,8	444	9,8 – 12,0	39,3 – 48,1	45	53	57	0,50	0,60	0,69	11,5	15	3,5
	214565	0,37	½	230	230	4,0	672	7.3 – 8,9	19,5 – 23,9	51	59	62	0,52	0,64	0,73	14,4	15	4,5
	214567	0,55	¾	230	230	6,0	952	4,4 – 5,4	14,6 – 17,9	52	59	63	0,48	0,59	0,69	23,1	15	7
	214568	0,75	1	230	230	7,3	1260	3,3 – 4,1	12,8 – 15,6	56	62	64	0,54	0,66	0,75	28,3	20	9
4 Inch Cap Start Cap Run	224560	1,1	1 ½	230	230	8,9	1638	2,6 – 3,1	6,4 – 7,8	58	65	68	0,59	0,71	0,80	39,6	20	12
	224561	1,5	2	230	230	11,1	2247	2.2 – 2,7	7,1 – 8,6	60	66	68	0,71	0,81	0,88	53,4	30	15
	224562	2,2	3	230	230	15,9	3219	1,2 – 1,6	3,9 – 4,7	61	68	70	0,72	0,82	0,88	88,0	50	25

Main winding – brown to blue
Start 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 – Three Phase Motors

Three phase motor cable selection

Table 10 Three-Phase Maximum Length of Copper Cable (meters)

3 Lead - DOL															
Motor Rating		Metric Cable Size, Square Millimeter, Copper Wire - 70 °C Rated Insulation													
Volts	kW	1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185
	.37	930	1550	2460	3670	6030	9460								
400V	.55	630	1050	1670	2500	4100	5860	9790							
50Hz	.75	490	820	1300	1950	3200	4330	7620							
	1.1	340	570	910	1360	2240	3200	5350	7280	9890					
	1.5	260	430	700	1040	1720	2340	4120	5630	7690					
	2.2	170	290	460	700	1150	1600	2770	3790	5190	6950	8950			
	3	120	210	340	510	840	1230	2030	2770	3790	5070	6530	7840	9190	
	3.7	100	170	270	410	680	980	1650	2260	3090	4140	5340	6420	7540	8750
	4	90	150	250	370	610	920	1480	2020	2770	3700	4750	5710	6680	7740
3	5.5	70	110	190	280	470	690	1140	1560	2140	2870	3700	4460	5240	6090
Lead	7.5	50	80	130	200	330	530	810	1110	1510	2030	2610	3130	3670	4250
DOL	9.3	0	?	?	?	?	?	?	?	?	?	?	?	?	?
	11	0	60	90	140	240	360	590	810	1120	1510	1950	2350	2770	3230
	15	0	0	70	110	180	270	450	620	860	1160	1500	1820	2150	2520
	18.5	0	0	0	80	140	210	350	490	680	910	1190	1440	1700	1990
	22	0	0	0	0	120	180	300	410	570	770	1000	1210	1440	1680
	30	0	0	0	0	0	130	220	310	420	570	740	900	1060	1230
	37	0	0	0	0	0	110	180	240	340	460	590	710	840	980
400V	45	0	0	0	0	0	0	150	200	280	380	490	600	700	820
50Hz	55	0	0	0	0	0	0	120	170	240	330	420	510	610	710
	67	0	0	0	0	0	0	0	?	?	?	?	?	?	?
3	75	0	0	0	0	0	0	0	0	180	240	320	390	460	530
Lead	83	0	0	0	0	0	0	0	0	0	?	?	?	?	?
DOL	90	0	0	0	0	0	0	0	0	0	190	240	290	350	400

6 Lead – WYE DELTA														
Volts	kW	2.5	4	6	10	16	25	35	50	70	95	120	150	185
	5.5	160	280	420	700	1110	1710	2340	3210	4300	5550	6690	7860	9130
400V	7.5	120	190	300	490	790	1210	1660	2260	3040	3910	4690	5500	6370
50Hz	9.3	?	?	?	?	?	?	?	?	?	?	?	?	?
	11	90	130	210	360	570	880	1210	1680	2260	2920	3520	4150	4840
6 Lead	15	60	100	160	270	430	670	930	1290	1740	2250	2730	3220	3780
WYE	18.5	40	70	120	210	340	520	730	1020	1360	1780	2160	2550	2980
DELTA	22	0	70	100	180	280	450	610	850	1150	1500	1810	2160	2520
	30	0	0	70	130	210	330	460	630	850	1110	1350	1590	1840
	37	0	0	0	100	160	270	360	510	690	880	1060	1260	1470
	45	0	0	0	90	130	220	300	420	570	730	900	1050	1230
400V	55	0	0	0	0	120	180	250	360	490	630	760	910	1060
50Hz	67	0	0	0	0	?	?	?	?	?	?	?	?	?
	75	0	0	0	0	90	130	190	270	360	480	580	690	790
	83	0	0	0	0	?	?	?	?	?	?	?	?	?
6 Lead	90	0	0	0	0	0	100	150	210	280	360	430	520	600
WYE	110	0	0	0	0	0	0	120	180	240	310	370	430	510
DELTA	130	0	0	0	0	0	0	0	150	210	270	330	390	450
	150	0	0	0	0	0	0	0	130	180	240	280	340	400
	185	0	0	0	0	0	0	0	0	0	?	?	?	?

Three phase motor performance data

Table 11 Three Phase 4" Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor

Type	Motor Model Prefix	Nameplate Rating				Full Load Watts	Line to line Resistance (Ohms)	Eff % at % load			Cos φ at % load			Locked Rotor Amps	Circuit Breaker	
		kW	Volts	Line Volts	Amps			50	75	100	50	75	100		Std.	Delay
	234561	0,37	400	400	1,1		54,4 – 66,4	56	63	66	0,53	0,65	0,70	4,7	15	1,2
	234562	0,55	400	400	1,6		36,8 – 45,0	58	64	67	0,54	0,67	0,75	6,4	15	1,8
	234563	0,75	400	400	2,1		25,4 – 31,0	60	67	69	0,52	0,65	0,75	9,3	15	2,5
	234524	1,1	400	400	3,0		13,0 – 15,9	66	71	73	0,53	0,67	0,76	14,5	15	3
4 Inch	234525	1,5	400	400	4,0		10,2 – 12,4	66	71	73	0,53	0,66	0,76	19,2	15	4,5
	234526	2,2	400	400	5,9		6,5 – 7,9	69	73	75	0,51	0,64	0,75	28,9	15	7
	234591	3	400	400	7,8		4,2 – 5,1	70	74	76	0,51	0,65	0,75	41,6	20	9
	234527	3,75	400	400	9,1		3,6 – 4,4	73	77	77	0,55	0,70	0,79	49	25	10
	234593	4	400	400	10,0		3,2 – 3,9	73	77	78	0,56	0,69	0,78	58	25	12
	234528	5,5	400	400	13,7		2,3 – 2,8	71	75	76	0,57	0,70	0,79	76	35	15
	234598	7,5	400	400	18,4		1,8 – 2,3	70	73	74	0,47	0,57	0,79	102	50	25

Table 12 Three Phase 6" Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor

Type	Motor Model Prefix	Nameplate Rating				Full Load Watts	Line to line Resistance (Ohms)	Eff % at % load			Cos φ at % load			Locked Rotor Amps	Circuit Breaker	
		kW	Volts	Line Volts	Amps			50	75	100	50	75	100		Std.	Delay
	236611	5,5	400	400	12,5		2,20 – 2,70	74	78	79	0,63	0,75	0,82	64	35	15
	236612	7,5	400	400	16,0		1,70 – 2,20	75	78	79	0,70	0,81	0,86	83	45	20
	236001	9,3	400	400	20,7		1,25 – 1,55	78	81	81	0,58	0,72	0,80	112	50	25
	236613	11	400	400	23,3		1,05 – 1,30	78	81	81	0,68	0,79	0,85	129	60	30
6 Inch	236614	15	400	400	31,3		0,75 – 0,94	79	81	81	0,70	0,80	0,85	169	80	35
	236615	18,5	400	400	38,5		0,59 – 0,73	80	82	82	0,69	0,79	0,85	231	100	45
	236616	22	400	400	45,3		0,48 – 0,60	81	83	83	0,71	0,81	0,86	268	125	55
	236617	30	400	400	63,5		0,32 – 0,40	80	83	83	0,67	0,79	0,84	393	175	75
	236618	37	400	400	73,0		0,25 – 0,32	82	84	84	0,72	0,82	0,87	410	200	90
	236619	45	400	400	93,9		0,22 – 0,27	82	84	86	0,70	0,80	0,84	514	250	110

Table 13 Three Phase 8" and 10" Motor Specifications (50 Hz), 2875 RPM, 1.0 Service Factor

Type	Motor Model Prefix	Nameplate Rating				Full Load Watts	Line to line Resistance (Ohms)	Eff % at % load			Cos φ at % load			Locked Rotor Amps	Circuit Breaker	
		kW	Volts	Line Volts	Amps			50	75	100	50	75	100		Std.	Delay
	239622	45	400	400	89		0,210 – 0,257	85	87	87	0,71	0,81	0,85	645	250	100
	239623	55	400	400	108		0,164 – 0,200	85	87	88	0,72	0,82	0,87	895	300	125
		67	400	400	133		0,2090	86	87	87	0,74	0,82	0,86	787	300	150
8 Inch	239624	75	400	400	145		0,102 – 0,125	85	87	87	0,72	0,82	0,87	1200	400	175
		83	400	400	160		0,1670	87	88	87	0,77	0,84	0,88	1077	400	175
	239125	93	400	400	190		0,083 – 0,101	84	86	87	0,68	0,78	0,83	1382	500	225
	239126	110	400	400	222		0,069 – 0,084	85	87	88	0,70	0,80	0,84	1597	600	300
	239127	130	400	400	252		0,063 – 0,078	86	87	88	0,79	0,84	0,87	1738	700	300
	239128	150	400	400	284		0,054 – 0,066	86	88	88	0,79	0,86	0,88	1858	800	350
	254233	110	400	400	232		0,1080	84	86	86	0,65	0,76	0,82	1158	600	300
10 Inch	264234	132	400	400	256		0,0789	87	88	88	0,74	0,82	0,86	1344	700	300
	264235	150	400	400	298		0,0730	86	88	87	0,73	0,81	0,85	1590	800	350
	264236	185	400	400	384		0,0570	86	88	88	0,64	0,75	0,81	2148	900	450

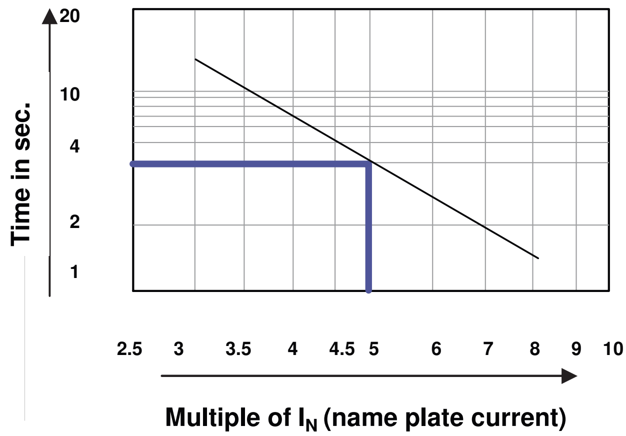
Performance is typical, not guaranteed, at specified voltages.
Locked rotor amps for Wye start 6 lead motors is 33% of value shown.
Performance also applies to 6 lead model numbers where not listed.

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 specfic 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 YÐ start

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

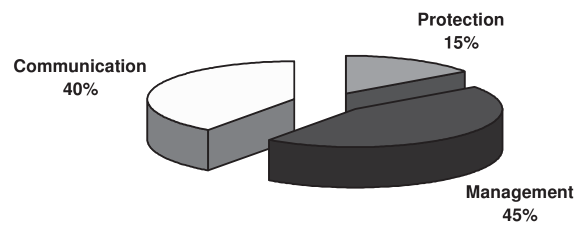
For Y Ð, relay must be incorporated in the delta circuit for adequate protection on Y start and set at I_N x 0.58. Recommended setting for all applications is the measured current value at duty point.

Setting > I_N is not allowed.

*Control Box Plus (incorporating **Blac Bocs**®)*

Motor/Pump Diagnosis, Management, Protection and Communication – all in one!

Two of the problems facing manufactures of motors, is not in the protection of the motors (as this is may be the symptom but not the problem) but in the communication of fault conditions, and in the managing a trip condition so as to minimize the down time.



The ***BLAC BOCS*** ® range of products was developed with this in mind.

Communication:

Without compromising on the protection aspect of the relay there was a larger portion of the processors capacity set aside for communication. The recording of current, voltage as well as the trip type allowed a person in the position of a data reader to extract the data and with fair accuracy detect potential problem areas using information that was previously unavailable. (The overload tripped but there is no record of the volts and amps at the time of trip) The inclusion of "trip time" (being how long the unit was off for)(max 45min) allows us to detect on going cycling previously undetected unless some one was present while this occurred. The data logging facility has successfully warned farmers that they are over pumping their borehole and stopped them from developing the last portion of their farm, as there was insufficient water to provide for this.In other cases a steady increase in amperage has indicated the need for preventive maintenance (prior to motor failure)

Management:
Once tripped what do you do? Far too many overloads are adjusted to accept a fault condition because they trip and remain off. Even more of the ***BLAC BOCS*** ® processor capacity was used in its management role. It was decided that only after 3 consecutive overload trips would the ***BLAC BOCS*** ® remain off as this indicated (under most circumstances) that the fault was here to stay. With the exception of this the ***BLAC BOCS***® will restart with varying intervals after every other trip type.

The under load trip time works on a fairly complex algorithm which allows the unit to remain off for longer in order to see if it can pump for longer thus deciphering the optimal recovery rate of the borehole. (Min. 15min to max. 4 hrs) under most circumstances this will achieve optimal yield from a borehole.

Protection:
Should a trip condition occur do not respond immediately first evaluate how life threatening it will be for the motor? If dangerous, respond within 4 seconds. If the danger is not immediate, wait a little longer to see if the situation will improve. If a short-circuit current takes place then the circuit-breaker will respond. The idea behind this is to provide the technician on site the opportunity to measure the current and voltage before the unit trips in order to assist with trouble shooting. We do not want the relay to be bridged out to achieve this.

Data collection: - The ***BLAC BOCS*** ® monitors the incoming voltage and current of the motor connected to the controller. The ***BLAC BOCS*** ® then calculates the power of the motor and takes action depending on the circumstances. Whenever a condition occurs, for instance overloading of the motor, the voltage and current of the motor is recorded in an on-board memory. This memory called an "EEPROM" (Electrically Erasable Programmable Read Only Memory), stores the data until it is read by the reader, or over-written with data created by new events.

The ***BLAC BOCS*** ® will record the last 120 events. These events include the following:

- Start of calibration (process whereby the commissioning officer verifies correct operating conditions and enters it into the ***BLAC BOCS***®)
- Calibration time out
- Last value that the system was calibrated at
- Under load current trip
- Over load current trip
- Unauthorised motor starting
- Level, pressure or switch off of motor (normal control input to the ***BLAC BOCS***®)
- Number of times motor started
- Number of times that the motor was calibrated
- Number of times that the voltage was either above or below motor specifications
- Motor rest period before running
- Actual motor running amps

Armed with this information, the data can be analysed to build an accurate history of the conditions that the motor was subjected to. Note that some of the mentioned events are for specific versions of the ***BLAC BOCS***®. The PC programme that is used to interpret the data automatically detects the correct version and displays the data accordingly.

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 Electric 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 14 kVAR Required 50 Hz

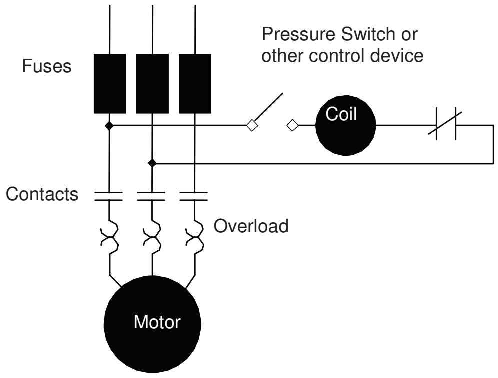
Motor		KVAR Required for P.F. of:		
kW	HP	0,90	0,95	1,00
3,7	5	0,8	1,5	3,1
4	5.5			
5,5	7.5	1,0	2,1	4,5
7,5	10	0,8	2.2	5,3
9,3	12.5			
11	15	1.1	3,3	7,8
15	20	1,8	4,3	9,6
18,5	25	3	6,5	14
22	30	3	7,5	17
30	40	5	10	22
37	50	5	12	27
45	60	5	12	30
55	75	5	15	37
67	90			
75	100	4	18	46
83	110			
93	125	18	35	72
110	150	18	38	82
130	175	13	37	88
150	200	10	37	95
185	250			

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.

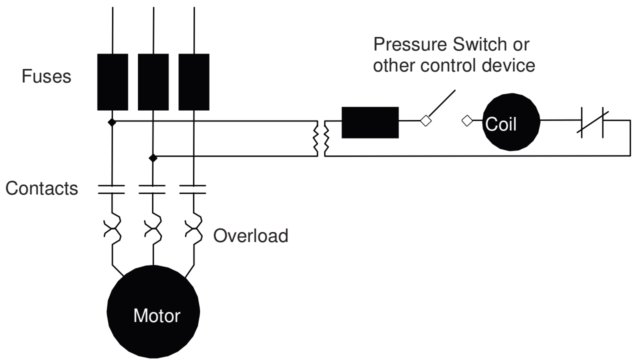
Line Voltage Control

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.



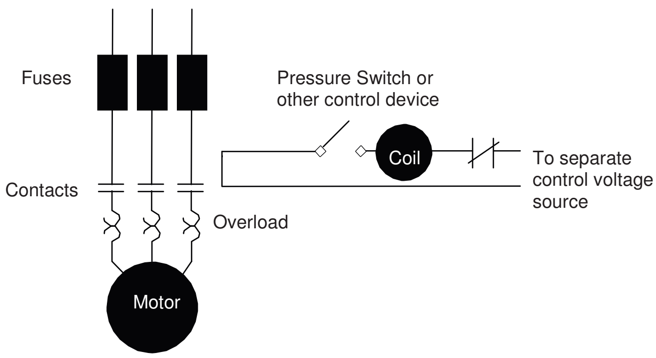
Low Voltage Transformer Control

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.



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.



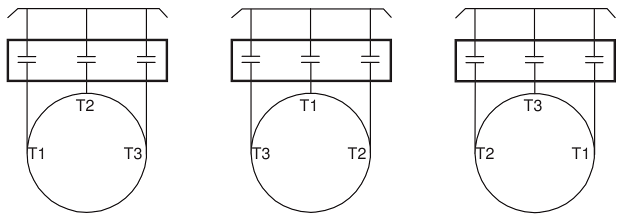
Checking and Correcting Rotation and Current Unbalance

1. Establish the 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.

1st Hook Up	2nd Hook Up	3rd Hook UP
L1 L2 L3	L1 L2 L3	L1 L2 L3



1st Hook Up	2nd Hook Up	3rd Hook UP
T1 = 50 amps	T3 = 51 amps	T2 = 50 amps
T2 = 49 amps	T1 = 46 amps	T3 = 48 amps
+T3 = 51 amps	+T2 = 53 amps	+T1 = 52 amps
Tot = 150 amps	Total = 150 amps	Total = 150 amps
$\frac{150}{3}$ = 50 amps	$\frac{150}{3}$ = 50 amps	$\frac{150}{3}$ = 50 amps
50 - 49 = 1 amp	50 - 46 = 4 amps	50 - 48 = 2 amps
$\frac{1}{50}$ = 0.02 or 2%	$\frac{4}{50}$ = .08 or 8%	$\frac{2}{50}$ = .04 or 4%

Phase designation of leads for CCW rotation viewing shaft end.

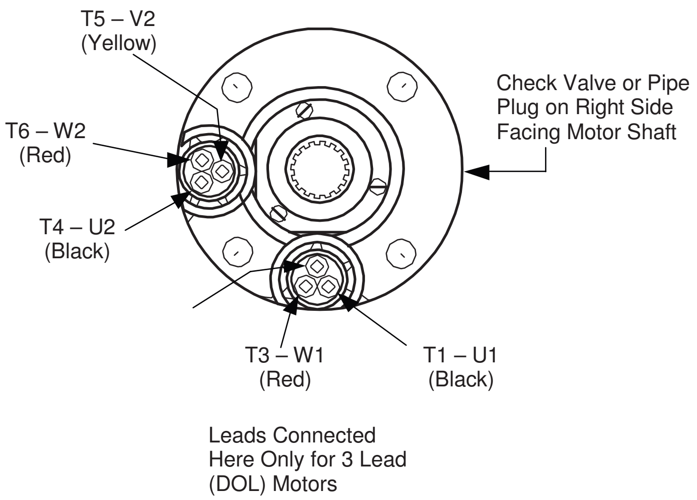
To reverse rotation, interchange any two leads.

Phase 1 or "A"- Black, T1, or U1
Phase 2 or "B"- Yellow, T2, or V1
Phase 3 or "C"- Red, T3, or W1

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

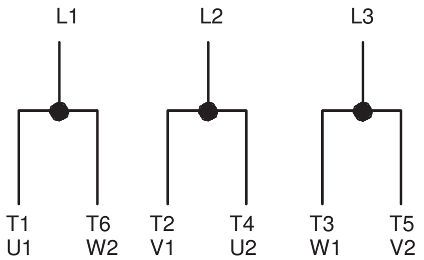
Three Phase Motor Lead Identification

90° Lead Spacing

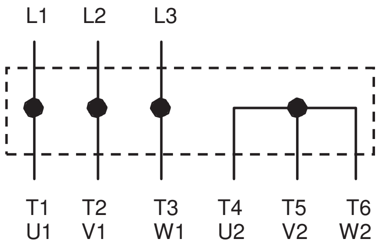


Line Connections – Six Lead Motors

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



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



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

Reduced Voltage Starters

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

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

With maximum recommended cable length, there is a 5% voltage drop in the cable, and there will be about 20% reduced starting current and about 36% reduction in starting torque compared to having rated voltage at the motor. This may be enough reduction in starting current so that reduced voltage starters may not be required. Standard three phase motors have three line leads so only resistance, autotransformer, or solid state reduced voltage starters may be used. The autotransformer type is preferred over resistance and solid state types because it draws lower line current for the same starting torque.

Wye-Delta starters are used with six lead Wye-Delta motors. All Franklin 6" and 8" three phase motors are available in six lead Wye-Delta construction. Consult the factory for details and availability. Part winding starters are not usable with Franklin Electric submersible motors. When reduced voltage starters are used, it is recommended that the motor be supplied with at least 55% of rated voltage to ensure adequate starting torque.

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

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

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

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

Inline Booster Pump Systems

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

1. **Horizontal Operation:** Horizontal operation is acceptable as long as the pump transmits thrust to the motor and the entire assembly is supported sufficiently to prevent binding stresses.
2. **Motor Support:** The motor support assembly must not restrict the flow of cooling water around the full diameter of the motor. The motor supports must be on the motor end-bell castings, and not on the motor shell.
3. **Motor Alterations:** On 6” and 8” motors, the sand slinger should be removed. The pipe plug covering the check valve should be removed from Ni-resist and 316 SS motors.
4. **Controls:** Franklin Subtrol-Plus is strongly recommended for all large submersibles. If Subtrol-Plus is not employed, properly sized ambient compensated quick-trip overloads must be utilized. In addition, a surge arrestor should be installed on all systems and properly grounded.
5. **Wiring:** Franklin’s lead assemblies are sized for submerged operation and may not be adequate for use in open air. Any wiring not submerged must comply with Franklin’s cable charts.
6. **Water Temperature:** The temperature of the water should be monitored at the inlet to each booster. When temperatures exceed 30℃, motor de-rating is required.
7. **Inlet Pressure:** The inlet pressure on each booster should be monitored and not be allowed below the pump’s specified Net Positive Suction Head Requirements (NPSHR). If NPSHR is unknown, at least 1.41 kg/cm^2 should be maintained at all times. **At no time should the pressure surrounding the motor be less than one atmosphere.**
8. **Discharge Flow:** The flow rate for each pump should not be allowed to drop below the minimum required maintaining cooling flow velocities. Pressure relieving valves should be employed to prevent running the pump at shut-off.
9. **Discharge Pressure:** The discharge pressure should be great enough to prevent up-thrust.
10. **Can Flooding:** An air bleeder valve must be employed on the booster can so that flooding may be accomplished prior to booster start-up. Once flooding is complete, the booster should be started as quickly as possible to minimize the chance of up-thrust. Water should never be forced through the booster can (more than momentarily) without the pump running as failure due to up-thrust may occur.

IMPORTANT NOTES:

1. **High Pressure Tests:** Motors intended for booster applications where the pressure exceeds 500 PSI must be special ordered from the factory.

Starting: Reduced voltage starting may be employed. This will reduce up-thrust on start, starting current, and mechanical stresses created by the motor’s high starting torque. Reduced voltage starters, if used should accelerate the motor to full speed within two seconds. Note: Solid state reduced voltage starters are not compatible with Subtrol-Plus.

Variable Speed Submersible Pump Operation, Inverter Drives

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

Warning: There is potential shock hazard from contact with insulated cables from a PWM drive to the motor.

- **Load Capability:** Pump load should not exceed motor nameplate service factor amps at rated voltage and frequency.
- **Volts/Hz:** Use motor nameplate volts and frequency for the drive base settings. Many drives have means to increase efficiency at reduced pump speeds by lowering motor voltage. This is the preferred operating mode.
- **Motor Current Limits:** Load no higher than motor nameplate service factor amps. For 50 Hz ratings, nameplate maximum amps are rated amps. See Overload Protection below.
- **Carrier Frequency:** Applicable to PWM drives only. These drives often allow selection of the carrier frequency. Use a low carrier frequency.
- **Voltage Rise-time or dV/dt:** Limit the voltage peak at the motor to 1000V and the rise time to no more than 2µsec. See filters and reactors.
- **Motor Overload:** Follow the Franklin guidelines listed in the Application Installation Maintenance (AIM) Manual on page 18.
- **Protection:** Drives with built-in motor protection will meet Franklin's quick-trip overload requirements. The ultimate trip (not the setting) must not exceed 115% of nameplate maximum amps in any line.
- **Subtrol-Plus:** Franklin's Subtrol-Plus protection systems
- ARE NOT USABLE on VFD installations.
- **Frequency Range:** Continuous between 25 and 60 Hz. Consult factory for operations above 50 Hz.
- **Start and Stop:** One second maximum ramp-up and ramp-down times between stopped and 25 Hz. Stopping by coast-down is preferable.
- **Successive Starts:** Allow 60 seconds before restarting.
- **Filters or Reactors:** Required if (1) Voltage is 380 or greater and (2) Drive uses IGBT or BJT switches (rise-times < 2 msec) and (3) Cable from drive to motor is more than 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.
- **Motor Cooling Flow:** The flow rate past the motor at rated nameplate motor frequency (Hz) must meet Franklin's minimum flow requirements. 4" 7.62 cm/sec. and 6" and 8" 15.24 cm/sec.

Installation – All Motors

Recommended minimum installation requirements

1 **CABLE SIZING**
Cable sizes MUST be based on the distance between the supply entry point (transformer) and the motor. See Franklin's cable selection charts or consult the cable manufacturer. Tie the cable to the rising main.

2 **EARTHING**
Use an Insulated earth wire, one size larger than the drop cable. Connect to the fourth wire of the motor lead out cable and M.O.V. Type arrestors. Arrestors MUST be installed as close to the motor (top of the borehole) as possible.

3 **PRESSURE GAUGE**
Preferably with drag pointer to indicate the presence of water hammer.

4 **NON-RETURN VALVE**
Surface non-return valves are optional.

5 **REGULATING VALVE**
A suitable control type valve, preferably one size smaller than the pipeline, is strongly recommended.

6 **WATERHAMMER:**
If surface valves are installed, a vacuum breaker must be fitted. Schrader (tyre valve) or brass check valves can be used. Air-release valve is NOT acceptable.

7 **UP-THRUSTING**
For boreholes with high static water levels, upthrusting on start-up can be minimised by using a smaller size rising main.

8 **LEVEL MEASUREMENT**
Dipper tube (open at the bottom) for measuring static and dynamic water levels. Tie the tube to the rising main.

9 **CORROSION CONTROL**
1/2 to 1 metre of screwed and socketed galvanised pipe. Connect pipe to the motor with a stainless steel conductor.

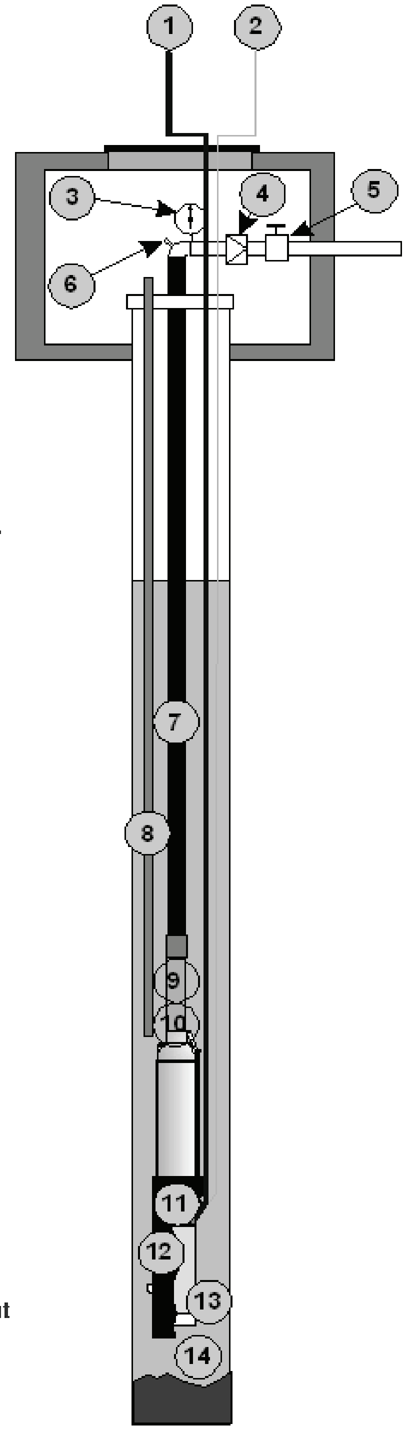
10 **NON RETURN VALVE**
A FULLY OPERATIONAL non return valve MUST be installed at the discharge of the pump.

11 **COUPLING AND SPLINE LUBRICATION**
The pump coupling must be filled with a good quality water resistant grease eg SHELL ALVANIA WR. Rotate the coupling while joining the motor to the pump.

12 **INDUCER SLEEVE**
An inducer sleeve MUST be fitted if the pump is installed below the main inflow point or if the inflow point is unknown.

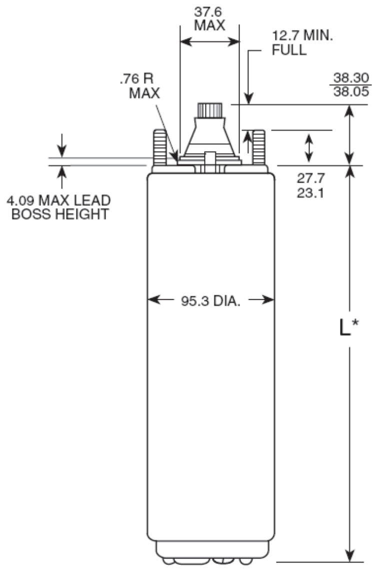
13 **MOTOR PROTECTION**
Motor protection must open the circuit within 10 seconds of a locked rotor, single phasing or dry running condition occurring.
Use a *CONTROL BOCS PLUS* or a *BLAC BOCS INTELLIGENT SYSTEM MANAGER*

14 **PREVENTING INGRESS OF SAND AND SILT**
Pump and motor must be installed a minimum of 5m from start of sediment or borehole bottom



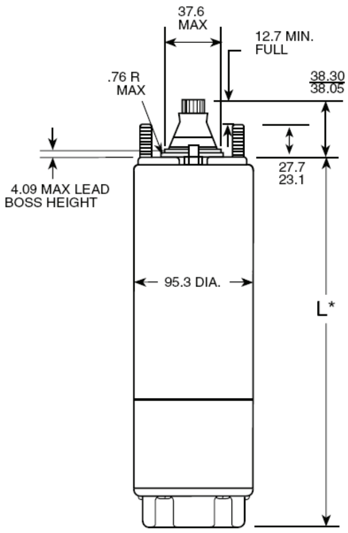
4” Super Stainless – Dimensions

(Standard Borehole)



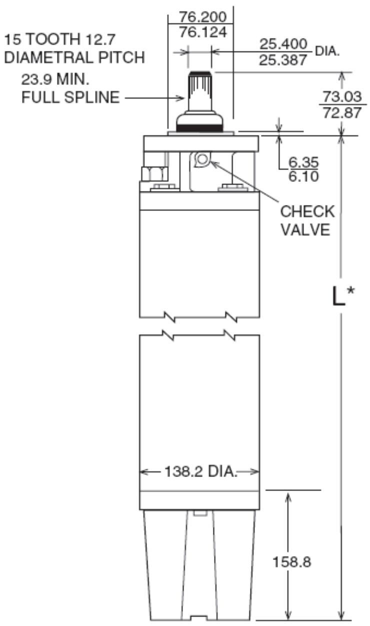
4” High Thrust - Dimensions

(Standard Borehole)



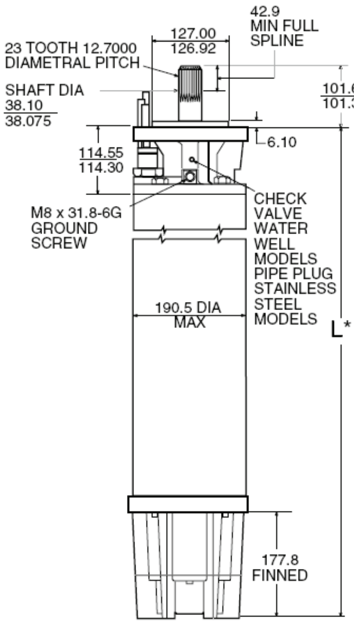
6” – Dimensions

(Standard Borehole)

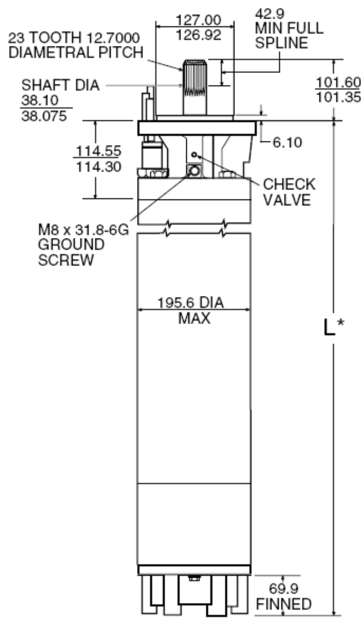


8” - Dimensions

(Standard Borehole)



40 to 100 HP



125 to 200 HP

Motor lengths and shipping weights are available on Franklin Electric’s web page (www.franklin-electric.com).

Tightening Motor Lead Connector Jam Nut

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

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

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

Pump to Motor Coupling

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

Shaft Height and Free End Play

Table 15 Shaft height and free end play

Motor	Normal Shaft Height	Dimension Shaft Height	Free End Play	
			Min.	Max.
4"	38,1 mm	38,30 mm / 38,05	0,25 mm	1,14 mm
6"	73,0 mm	73,02 mm / 72,88	0,75 mm	1,25 mm
8" Type 1	101,5 mm	101,60 mm / 101,35	0,20 mm	0,50 mm
8" Type 2	101,5 mm	101,60 mm / 101,35	0,89 mm	1,52 mm
8" type 2,1	101,5 mm	101,60 mm / 101,35	0,75 mm	2,03 mm

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

Submersible Leads and Cables

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

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

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

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

Splicing Submersible Cables

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

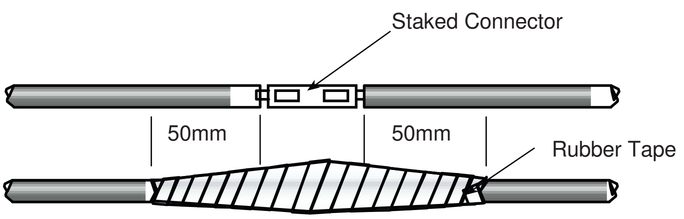
A. Strip individual conductor of insulation only as far as necessary to provide room for a stake type connector. Tubular connectors of the staked type are preferred. If connector outside diameter (OD) is not as large as cable insulation, build up this area with rubber electrical tape.

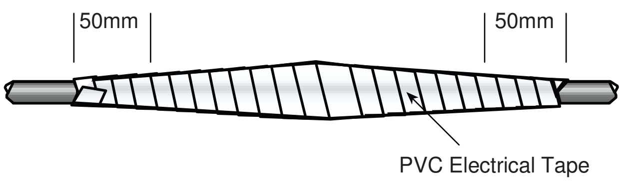
B. Tape individual joints with rubber electrical tape, using two layers, with the first layer extending two inches beyond each end of the conductor insulation end, and the second layer extending two inches beyond the ends of the first layer. Wrap tightly, eliminating air spaces as much as possible.

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

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

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





Maintenance – All Motors

System Trouble Shooting

Table 16 Trouble shooting - motor does not start

Possible Cause	Checking Procedures	Corrective Action
A. No power or incorrect voltage.	Check voltage at line terminals. The voltage must be ± 10% of rated voltage.	Contact power company if voltage is incorrect.
B. Fuses blown or circuit breakers tripped	Check fuses for recommended size and check for loose, dirty or corroded connections in fuse receptacle. Check for tripped circuit breakers.	Replace with proper fuse or reset circuit breakers.
C. Defective pressure switch.	Check voltage at contact points. Improper contact of switch points can cause voltage less than line voltage.	Replace pressure switch or clean points.
D. Control box malfunction.	For detailed procedure, see pages 32-33.	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 30-32.	Repair or replace.

Table 17 Trouble shooting - 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 Trouble Shooting

Table 18 Trouble shooting - motor runs continuously

Possible Cause	Checking Procedures	Corrective Action
A. Pressure switch.	Check switch for welded contacts. Check switch adjustments.	Clean contacts, replace switch, or adjust setting.
B. Low water level in well.	Pump may exceed well capacity. Shut off pump, wait for well to recover. Check static and drawdown level from well head.	Throttle pump output or reset pump to lower level. Do not lower if sand may clog pump.
C. Leak in system.	Check system for leaks.	Replace damaged pipes or repair leaks.
D. Worn pump.	Symptoms of worn pump are similar to those of drop pipe leak or low water level in well. Reduce pressure switch setting, if pump shuts off worn parts may be the fault.	Pull pump and replace worn parts.
E. Loose coupling or broken motor shaft.	Check for loose coupling or damaged shaft.	Replace worn or damaged parts.
F. Pump screen blocked.	Check for clogged intake screen.	Clean screen and reset pump depth.
G. Check valve stuck closed.	Check operation of check valve.	Replace if defective.
H. Control box malfunction.	See pages 32-33 for single phase.	Repair or replace.

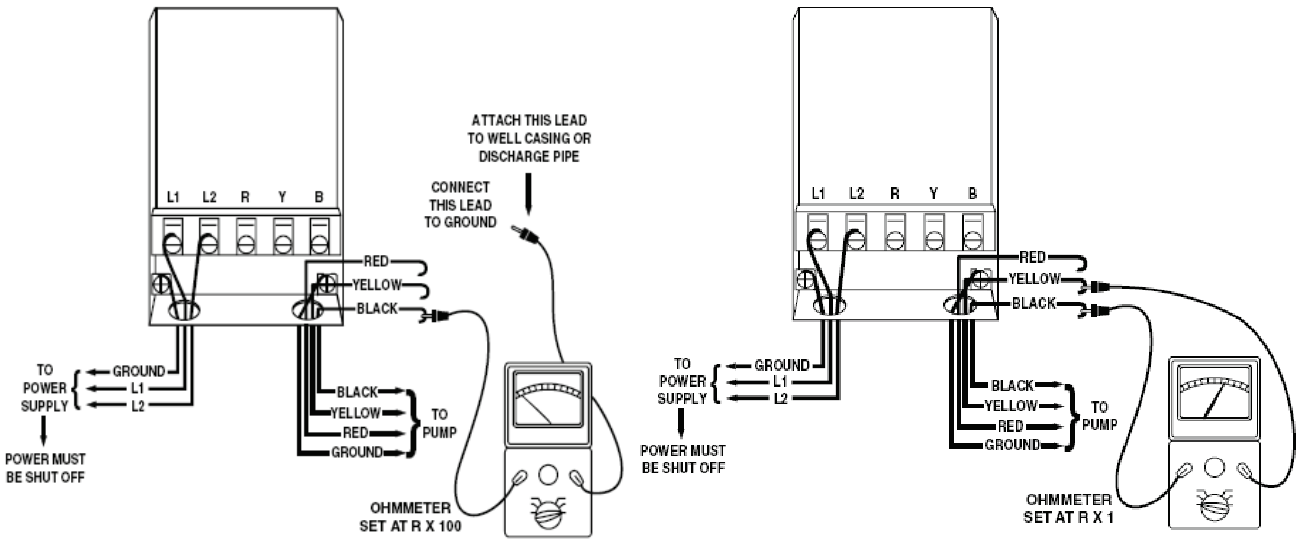
Table 19 Trouble shooting - motor runs but overload protector trips

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 32-33.	Repair or replace.
D. Defective motor or cable.	For detailed procedures, see pages 30-32.	Repair or replace.
E. Worn pump or motor.	Check running current, See pages 13, 16 & 17.	Replace pump and/or motor.

Preliminary tests

Table 20 Preliminary tests - all sizes single and three phase

"Test"	Procedure	What it Means
Insulation Resistance	1. Open master breaker and disconnect all leads from control box or pressure switch (QD type control, remove lid) to avoid electric shock hazard and damage to the meter. 2. Set the scale lever to R X 100K and set the ohmmeter on zero. 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 31), the motor is not grounded and the cable insulation is not damaged. 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. 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. 3. On 3-wire motors measure the resistance of brown to blue (Main winding) and brown to black (Start winding). Three phase motors measure the resistance line to line for all three combinations.	4. If all ohms values are normal (Tables 13, 16 & 17), the motor windings are neither shorted nor open, and the cable colors are correct 5. If any one value is less than normal, the motor is shorted. 6. 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. 7. If some ohms values are greater than normal and some less on single-phase motors, the leads are mixed. See Page 32 to verify cable colors.



Insulation Resistance Readings

Table 21 Normal ohm and megohm valves between all leads and ground

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

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

Table 21 is based on readings taken with a megohmmeter with a 500V DC output. Readings may vary using a lower voltage ohmmeter, consult Franklin Electric if readings are in question.

Resistance of Drop Cable (Ohms)

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

Winding Resistance Measuring

The winding resistance measured at the motor should fall within the values in Tables 13, 16 & 17. When measured through the drop cable, as shown in Figure 14, page 30, the resistance of the drop cable as determined from the chart below, must be subtracted from the ohmmeter reading to get the winding resistance of the motor.

.

Drop Cable Resistance

Table 22 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

Maintenance – Single phase Motors and Controls

Identification of Cables when Colour Code Is Unknown (single-phase)

If the colors on the individual drop cables cannot be found with an ohmmeter, measure:
Cable 1 to Cable 2
Cable 2 to Cable 3
Cable 3 to Cable 1
Find the highest resistance reading.

The lead not used in the highest reading is the common lead. Use the common lead and each of the other two leads to get two readings:

Highest is the start lead.
Lowest is the main lead.

EXAMPLE:
The ohmmeter readings were:
Cable 1 to Cable 2—6 ohms Cable 2 to Cable 3—2 ohms Cable 3 to Cable 1— 4 ohms

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

From the common lead, the highest reading (4 ohms) was to Cable 1—Start

From the yellow lead, the lowest reading (2 ohms) was to Cable 2—Main

Standard Single-phase Control Boxes

Checking and Repairing Procedures (Power On)

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

A.) VOLTAGE MEASUREMENTS

Step 1. Motor Off

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

Step 2. Motor Running

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

B.) CURRENT (AMP) MEASUREMENTS

1. Measure current on all motor leads.
2. Amp Reading: Current in 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 and brown motor leads and lower than normal in the black motor lead.
5. A bound pump will cause locked rotor amps and overloading tripping.
6. Low amps may be caused by pump running at shutoff, worn pump, or stripped splines.
7. Failed start capacitor or open relay are indicated if the black lead current is not momentarily high at starting.

CAUTION: The test 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.

Ohmmeter Tests

QD Control Box (Power Off)

A. START CAPACITOR
Meter Setting: R x 1,000.
Connections: Capacitor terminals.
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 kohms (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

Jumbo 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 test 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.

Control Box Plus (incorporating ***Blac Bocs***) trouble shooting

Light indication or Symptom	Possible Cause	Solution
Unit appears dead	No power to the unit or unit faulty.	Check wiring. AC power should be applied to L1 and L2/N. In some cases the pressure switch or other control device may be wired to the power input. Check that the control switch is wired strictly according to the instructions. Using an ohm meter check the power supply transformer of the unit by removing all power and measuring the resistance between L and N (single phase) or L1 and L3 (three phase) If the reading shows infinity the unit is damaged. Return to the factory for service.
RED AND GREEN light on while pump is running	All OK	-
RED light on and GREEN light flashing while pump is running	Supply voltage is less than 90% of nominal	If condition occurs intermittently installation will work satisfactorily. If condition remains contact electrician to investigate supply
RED light flashing and GREEN light on while pump is running	Supply voltage is more than 110% of nominal	If condition occurs intermittently installation will work satisfactorily. If condition remains contact electrician to investigate supply
Lights flashing RED-RED-GREEN and pump not running	Supply voltage exceeded 115% of nominal	Wait 3 minutes for retry. If condition prevails, contact electrician to attend to AC supply
Lights flashing GREEN-GREEN-RED and pump not running	Supply voltage below 80% of nominal	Wait 3 minutes for retry. If condition prevails, contact electrician to attend to AC supply
Red light on constantly	An overload was detected.	***CONTROL BOCS PLUS ®*** is switched off at the ON/OFF or external switch1 **OR** 3 overloads in a row caused a lock-out condition Switch on and see if overload clears **OR** remove power from the ***CONTROL BOCS PLUS ®*** for at least 5 seconds. Pump will re-start within 90 seconds of reapplying power
RED light flashing	Overload condition has been detected	The motor will auto restart within 15-60 minutes depending on the severity of the overload condition. To reset manually, switch off and on again. DO NOT DO THIS MORE THAN TWICE. Correct the fault before attempting any further starts
GREEN light on	A dry run or under	Switch on and resume pumping. A float

Light indication or Symptom	Possible Cause	Solution
constantly	load has been detected and the ON/OFF switch or external control switch has opened	switch or other external control switch may have opened. Check for external witches or control Devices
GREEN light flashing time. A fast flash rate indicates a few minutes	A dry run or under load has been detected	The motor will restart automatically within 15-240 minutes. Light flash rate is proportional to the amount of time left. Slow flash indicates up to 4 hours waiting

QD Standard Control Box Parts List

Table 23 Q.D. Control Box Components 50Hz

Model	kW	Volts	Relay	Capacitor	Capacitor Rating	Capacitor Overload Asm.	Overload
2803530115	0,25	230	155031112	275461123	43-53 Mfd. 330V	151033957	155250101
2803550115	0,37	230	155031112	275461123	43-53 Mfd. 330V	151033957	155250101
2803570115	0,55	230	155031112	275461108	59-71 Mfd. 330V	151033906	155250102
2803580115	0,75	230	155031112	275461106	86-103 Mfd. 330V	151033918	155250103

The replacement kit for relay 155031112 is 305213912

Table 24 Capacitor Replacement Kit

Capacitor	Kit
275461106	305205906
275461108	305205908
275461123	305205923

Table 25 Cap/Overload asm. Replacement Kit

Capacitor	Kit
151033906	305218906
151033918	305218918
151033957	305218957

Jumbo Standard Control Box Parts List

Table 26 Control Box Components, 1.1 KW and larger 50Hz.

Model	kW	Volts	Relay	Capacitor Start	Capacitor Run	Overloads.
2823508110	1,1	230	155031112	275464113 105-126 Mfd. 220V	155328102 10 Mfd. 370V	275411114
2823518110	1,5	230	155031112	275468115 189-227 Mfd. 220V	155328103 20 Mfd. 370V	275411102 run 275411106 start
2823528110	2,2	230	155031112	275468119 270-324 Mfd. 220V	155327102 35 Mfd. 370V	265406107 run 275411107 start

The replacement kit for relay 155031112 is 305213912

Table 27 Capacitor Replacement Kit

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

Table 28 Overload Replacement Kit

Overload	Kit
275406102	305214902
275406107	305214907
275411102	305215902
275411106	305215906
275411107	305215907
275411114	305215914

Standard Control Box Wiring Diagrams

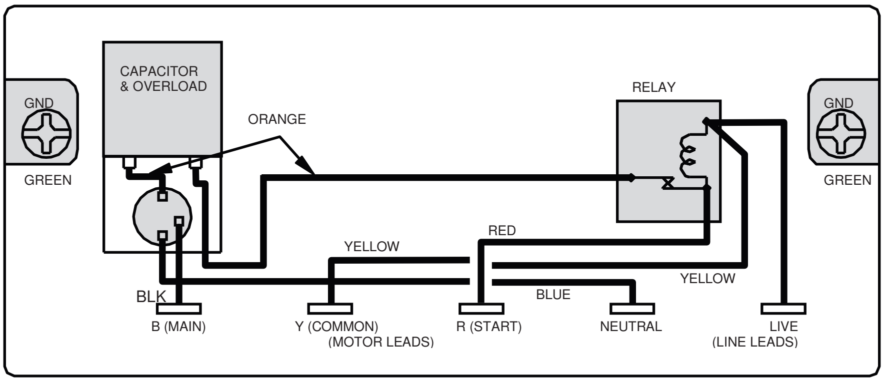


Figure 6 Control box wiring diagram - 0.25kW - 0.75kW 230V 4"

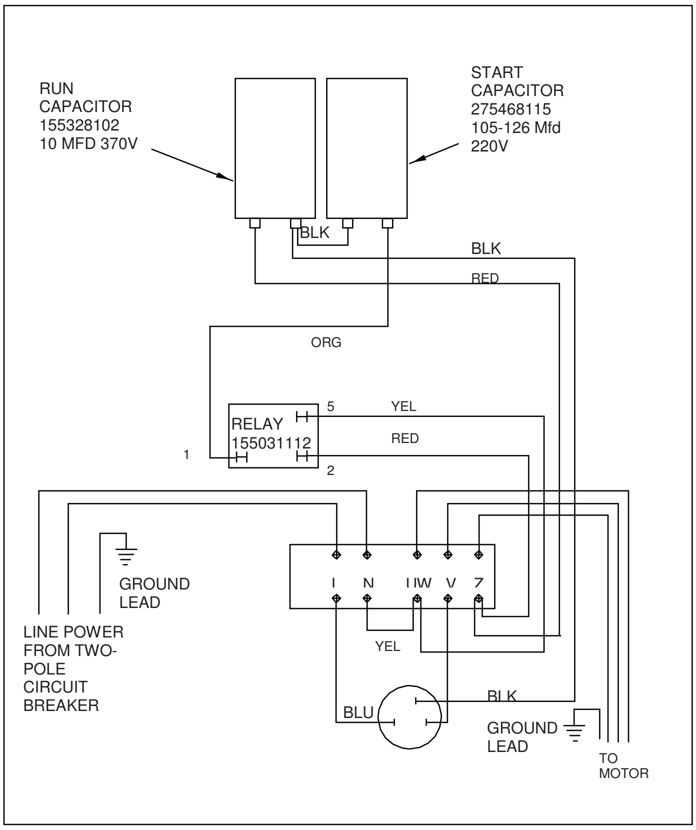


Figure 7 Control box wiring diagram - 1.1kW 230V 4"

Standard Control Box Wiring Diagrams

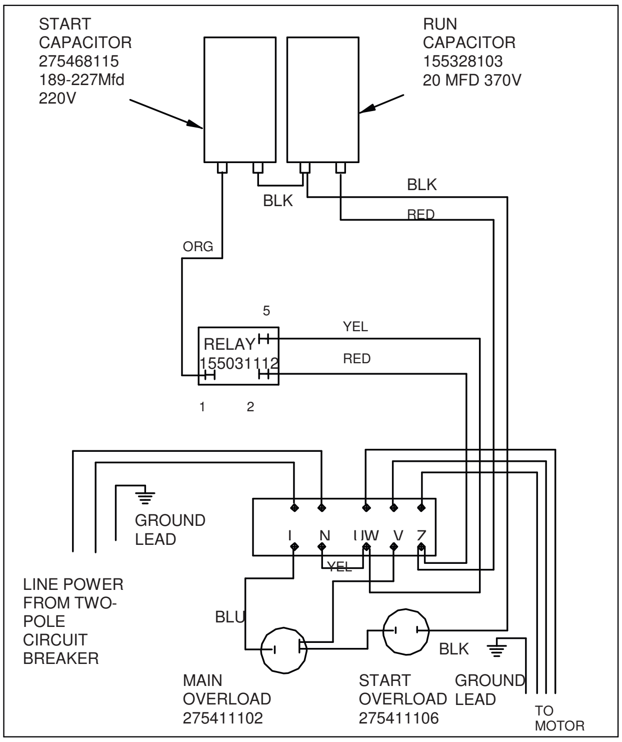


Figure 8 Control box wiring diagram - 1.5kW 230V 4"

Where:
BLK = Black
BLU = Blue
YEL = Yellow
RED = Red
ORG = Orange

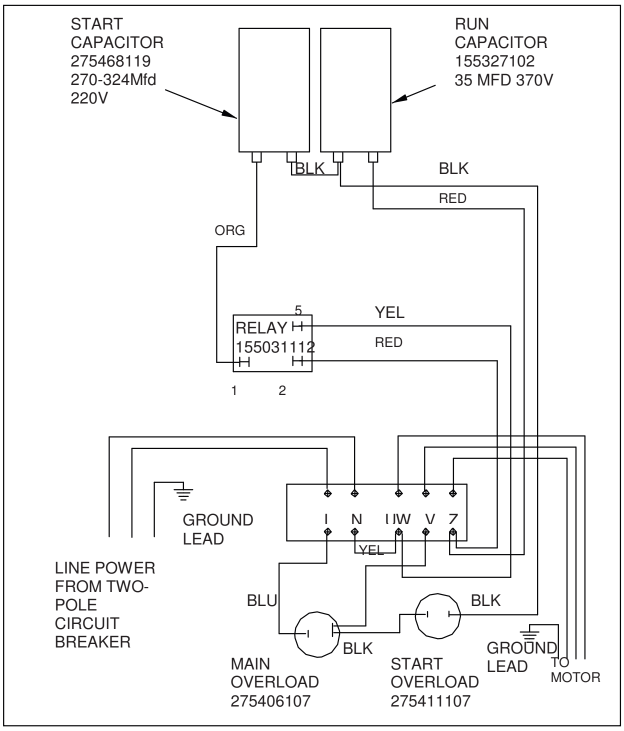


Figure 9 Control box wiring diagram - 2.2kW 230V 4"