GRUNDFOS SUBMERSIBLE MOTOR GUIDE

MS/MMS

Application - Installation - Maintenance
60Hz, Single-Phase and Three-Phase Motors

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History of GRUNDFOS

Founded in 1945 in Bjerringbro, Denmark, Grundfos is a global pump and pumping systems provider with an annual production of more than 16 million units. To support plans for strategic growth in North America, Grundfos acquired Paco, Peerless and Yeomans Chicago, which have added valuable resources and competencies to the region.

These acquisitions enable Grundfos to offer a wide range of solutions for both water and wastewater applications. From multistage industrial and submersible pumps, to disinfection systems and chemical feed systems, the Grundfos portfolio offers solutions to your individual needs.

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GRUNDFOS

SAFETY FIRST!

Do not think that reading this manual in any way, allows you or anyone else to operate electrical test equipment or work with electrical equipment, without proper training and license. This type of work should only be carried out by someone trained and certified.

ATTENTION!
IMPORTANT INFORMATION FOR INSTALLERS OF THIS EQUIPMENT!

This equipment is intended for installation by technically qualified personnel only.
Failure to install this equipment in compliance with national and local electric codes, and within Grundfos recommendations may result in electrical shock or fire hazard, unsatisfactory performance, equipment failure and other problems.

Additional Grundfos installation information is available in Data Booklets and in Instruction and Owners Manuals (I&O). To obtain a Data Booklet or I&O, contact Grundfos directly or a local Distributor.

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 motor cable, to the power supply ground terminal using wire no smaller than motor cable wires.

To reduce the risk of electrical shock, disconnect power supply before working on, or around the water system.

Do NOT use motor in swimming areas.

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Motor Storage

Grundfos submersible motors contain food grade liquid for lubrication, cooling and freeze protection. The motor liquid contains monopropylene glycol. Minor motor liquid loss will not damage the motor. Grundfos MS402 motors have filtered check valves that allow water into the motor is not uncommon during operation to replace any fluid that may escape as the motor temperature changes.

Motors that have been **removed** from service may no longer have frost protection due to this fluid exchange, and should not be stored in temperatures below 32°F (0 °C).

Long-term storage of submersible motors can have a negative effect on shaft seal and motor fluid level. Storage time should not exceed 5 years without periodic inspection. Motor storage time can be extended to a maximum of 5 years by rotating the shaft periodically and by checking the motor liquid level once each year. Contact a Grundfos Technical Sales Manager (TSM) for proper motor liquid check procedure.

Number of Starts

Grundfos MS and MMS motors are designed for continuous or intermittent operation. Frequent motor starts can create excessive heat in the motor windings and negatively affect the life of the motor and other system components. Motor start draws more amperage than run. Higher amp draws make higher heat that can cause damage to motor winding or insulation.

Refer to Table 1 for maximum and minimum number of starts per hour and per day. For maximum motor life, the number of starts should not exceed these limits. Proper pump selection and system setup will allow for operation within these guidelines.

Number of Motor Starts

Motor types Standard, N, R, versions	HP ranges	Minimum starts per year	Maximum starts per hour	Maximum starts per day
MS 402	1/2 - 2	1	100	300
MS 4000	2 - 10	1	100	300
MS 6000C	7-1/2 - 40	1	30	300
MMS 6	50 - 60	1	10	70
MMS 8000	40 - 150	1	8	60
MMS 10000	175 - 250	1	6	50

Table 1

Note: Using VFD can start motors more frequently.
Standard = 304 Stainless Steel
N = 316 Stainless Steel
R = 904L Stainless Steel
Motor installed position does not affect the number of motors start table. Same number starts vertical, angled or horizontal.

Installation Position

Motors can be installed either horizontally or vertically. **See Fig. 1** in either position, the motor must be sleeved and fully submerged at least one foot to prevent vortex (air entering intake).

When a motor is installed in a horizontal position, the shaft must not fall below the horizontal plain. Grundfos recommends that a Flow Sleeve be installed on all motors mounted in a horizontal position. Make sure that the motor is fully supported when mounted in the horizontal position. See Flow Sleeve section on **page 12**.

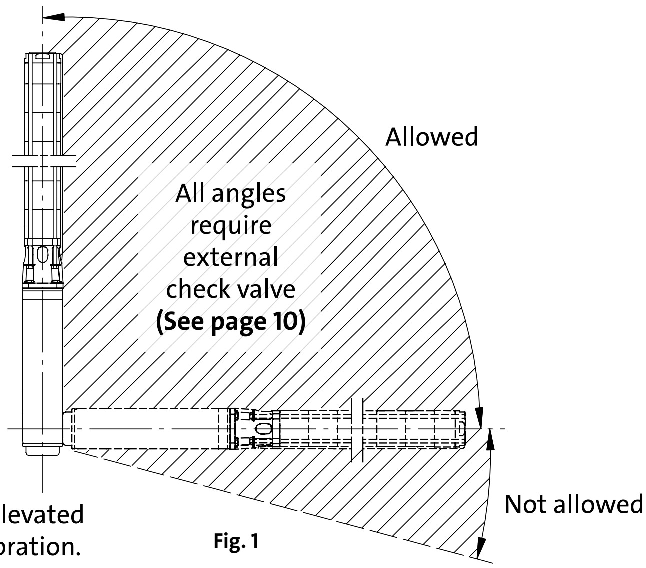


Fig. 1

Note: Do not let pump sit on bottom of tank. Place on an elevated surface for cooling, to avoid injesting debris and absorb vibration.

Transformer Capacity

Adequately sized transformers are necessary to satisfy the kVA requirements of the submersible motor. Undersized transformers may supply voltage below that required for proper motor operation.

Other loads on the system must be added directly to the kVA requirement of the submersible motor for proper sizing of the transformer bank. **See Table 2** for proper transformation sizing.

Transformer Capacity KVA Requirements

Submersible Motors				Smallest kVA Rating - Each Transformer	
Motor HP / kW Rating		kW Rating	Total Effective kVA Required *	Open WYE or DELTA 2 Transformers	WYE or DELTA 3 Transformers
Single Phase	Three Phase				
1-1/2	1-1/2	1.1	3.0	2.0	1.0
2	2	1.5	4.0	2.0	1.5
3	3	2.2	5.0	3.0	2.0
5	5	3.7	7.5	5.0	3.0
7-1/2	7-1/2	5.5	10.0	7.5	5.0
10	10	7.5	15.0	10.0	5.0
15	15	11.0	20.0	15.0	7.5
	20	15.0	25.0	15.0	10.0
	25	18.5	30.0	20.0	10.0
	30	22.4	40.0	25.0	15.0
	40	29.8	50.0	30.0	20.0
	50	37.3	60.0	35.0	20.0
	60	44.7	75.0	40.0	25.0
	75	55.9	90.0	50.0	30.0
	100	74.6	120.0	65.0	40.0
	125	93.2	150.0	85.0	50.0
	150	111.9	175.0	100.0	60.0
	175	130.5	200.0	115.0	70.0
	200	149.2	230.0	130.0	75.0

Table 2

* Pump motor kVA requirements only - Does not include allowances for other loads.

Note: Standard kVA ratings are shown in **Table 2**. If the utility company allows transformer loading higher than standard, higher loading values may be used to meet total effective KVA required. Correct voltage and balance must be maintained.

IDENTIFYING TRANSFORMER TYPES

Transformer configurations like Open Delta or Wye Connections (2 Pot Systems) are common in power distribution systems. Care must be taken with these transformer configurations to assure a consistent voltage balance, as voltage unbalance can lead to a reduced life span of the motor. Refer to **pg. 45** for proper calculation of voltage/current balance.

When connecting a Grundfos submersible motor to an Open Delta or Wye connections transformer system, consider the following;

1) These transformer connections deliver 3 phase current to the motor. They differ from 3-pot systems in that the one high voltage leg will have a higher current value, voltage will not be 120 degrees apart and the third voltage leg is produced by the 2-pot transformer system.

2) An Open Delta or Wye transformer configuration will show a severe voltage/current unbalance.

3) The Open Delta or Wye transformer connection can only be operated at 58% of the 3-pot transformer configuration.

In motor control systems where a VFD (Variable Frequency Drive), reduced voltage starters and/or pump protection equipment has been installed; Open Delta or Wye connected transformer systems can fault on loss of leg on the incoming power side. To remedy this fault condition, loss of leg protection can be disabled. However, disabling the loss of leg fault protection limits the total motor protection available.

Open Delta (Wire Connection)

Full Three-Phase Power Supply

For 3 Phase systems, a full 3 Phase Delta transformer configuration is recommended. This system might include three individual transformers, (one for each voltage leg) or one single 3 phase transformer that includes all three transformers in one contained unit. Although this system delivers voltage/current on each individual power leg it does not guarantee good balanced power. Heavy single-phase loads or faults on the transmission line could produce an unbalanced load. It is recommended that the voltage/current be inspected for balance and adjusted accordingly to achieve the lowest unbalance possible.

Generators (two types):
internally regulated and externally-regulated.

Internally-regulated generators have an additional winding in the generator stator. The extra winding senses the output current and increases/ decreases the output voltage automatically.

Externally-regulated generators use an externally mounted voltage regulator that senses output voltage. As the voltage dips at motor start-up, the regulator increases the output voltage of the generator. An externally-regulated generator is to be sized approximately 50% higher in kW/ kVA rating to deliver the same starting torque as an internally regulated generator. **Internally-regulated generators normally have the best running efficiency**.

Generator frequency (Hz) should match the motor nameplate frequency rating. Operating a motor at a frequency other than its rated frequency will effect pump performance and could overload the motor.

Sizing a generator to the motor is critical. **Table 3 (to the right)** should be used as a guideline for selecting the proper generator. The generator manufacturer may also have helpful guidelines for proper sizing.

Engine-Drive Generator Size Requirements
Submersible Motors Single Phase or Three Phase

HP	kW	Externally Regulated		Internally Regulated	
		kW	kVA	kW	KVA
1/2	0.37	2.0	2.5	1.5	1.9
3/4	0.56	3.0	3.8	2.0	2.5
1	0.75	4.0	5.0	2.5	3.1
1-1/2	1.10	5.0	3.3	3.0	3.8
2	1.50	7.5	9.4	4.0	5.0
3	2.20	10.0	12.5	5.0	6.3
5	3.70	15.0	18.8	7.5	9.4
7-1/2	5.50	20.0	25.0	10.0	12.5
10	7.50	30.0	37.5	15.0	18.8
15	11.0	40.0	50.0	20.0	25.0
20	15.0	60.0	75.0	25.0	31.0
25	18.5	75.0	94.0	30.0	37.5
30	22.4	100.0	125.0	40.0	50.0
40	29.8	100.0	125.0	50.0	62.5
50	37.3	150.0	188.0	60.0	75.0
60	44.7	175.0	220.0	75.0	94.0
75	55.9	250.0	313.0	100.0	125.0
100	74.6	300.0	375.0	150.0	186.0
125	93.2	375.0	469.0	175.0	219.0
150	111.9	450.0	563.0	200.0	250.0
175	130.5	525.0	656.0	250.0	313.0
200	149.2	600.0	750.0	275.0	344.0

Table 3

Add 50% to generator rating for proper sizing of a 2-Wire submersible motor.

General generator sizing guidelines: Do not exceed 490 feet above sea level, 60% relative humidity and 86 °F maximum inlet air temperature. If these limits are exceeded, the standard diesel engine and possibly the generator will need to be derated in order to give the motor sufficient power supply. When ordering a generator set, altitude, air inlet temperature and maximum humidity should be given to the generator manufacturer for proper sizing. Generator sets for Three-Phase submersible motors must be able to withstand 35% voltage reduction during start-up.

For the selection of an internally regulated generator when applied to DOL start single phase or three phase motors, refer to the kW rating in **Table 3**.

ALWAYS:
- Always make sure the fuel filter is clean and the fuel is good so the generator runs smooth.
- Always start the generator before starting the motor.
- Always stop the motor, before stopping the generator.
- Always run the generator at full RPM while motor is in operation. Consult with the generator manufacturer for proper sizing and selection of generators.
- Always make sure to use a properly sized pump panel with built in pump protection

NEVER:
- Never allow the generator to run out of fuel.
- Never run other items off one or two legs of the power going to the pump as this may cause three phase unbalance of the power

WARNING: If the generator is to be used as standby or back-up to the power grid, an automatic or manual transfer switch must be used. Contact the utility company for proper use and approval.

Check Valves
Grundfos submersible pumps are equipped with a reliable check valve in the pump discharge, which prevents back flow when the pump stops. The short closing time of the check valve helps to reduce the risk of destructive water hammer.

Check valves built into SP pumps are intended for vertical pump applications. When installing a pump at an angle, installation requires an additional check valve to be installed in the discharge piping. This prevents misalignment or failure to seat the pump's check valve at an angle. Additional check valves for discharge piping are sold separately.

When installing a pump without a built-in check valve, an in-line check valve should be installed in the discharge pipe 25 feet from the pump. For deeper settings, check valves should be installed per 200 feet of discharge pipe.

Swing check valves are not recommended in submersible pump applications. Swing check valves have a tendency to close slowly, resulting in a back flow of fluid. Back flow can cause the motor to rotate backwards, which can damage the motor. Additionally, there is an opportunity for air to be introduced into the drop pipe which will create the potential for water hammer at startup.

Upthrust:
In the case of very low counter pressure at start-up, there is risk that the entire pump chamber stack and motor shaft may rise. This is called upthrust. Upthrust can damage both the pump and motor. Grundfos pumps and motors are protected against upthrust occurring during the critical start-up phase. The protection consists of either a built-in stop ring, or hydraulic balancing. This protection handles first time pipe fill in new applications. Repeated upthrust conditions will challenge the life of a pump and motor in applications where there is no check valve, a leaking check valve, or a drilled check valve where the pipe drains every cycle.

Cavitation:
Cavitation occurs when water is pulled apart, causing a void or a gap in the pipe. This void is under vacuum. When the pump comes on and water replaces the void under vacuum, the two water surfaces collide making a loud noise and causing vibration. There are many conditions that can cause cavitation.

Water Hammer occurs when:
- Closing a faucet or valve quickly, causing a pressure shock wave back thru the line that collides in a closed system.
- Not enough check valves in the water supply piping.
- The first check valve above the pump is 30 feet above the standing water level (lowest static level), or one of the lower check valves is leaking and an upper check valve holds. In these cases, the forces can pull the water apart and create a void (vacuum bubble) in the water.

Since water hammer often occurs when the pump starts up or shuts off, an end user might assume that the pump is the cause of the problem. However, there is usually some condition in the piping check valve or system that is the root cause of water hammer.

To prevent Water Hammer:
- Adding a check valve in the vertical piping from the pump.
- Removing any air from the pipes that vibrate.
- Improving piping mounting by adding dampeners between the pipe and the surface it is mounted to.
- Velocities within the pipeline should be maintained within accepted design ranges of 3 fps on horizontal runs and 5 fps on vertical runs.
- Valve closure should not be instantaneous. The larger the piping and or greater the fluid velocity the slower the valve closure should be.
- Vacuum breaks should be placed at all locations where the momentum of the fluid is likely to continue pulling a vacuum when fluid is stopped abruptly.
- Use a VFD or Soft Start with a 1 second ramp up to maximum frequency.
- Use a VFD that allows for a Line Fill for a certain time at a slower hz.

Submersible motors require cooling flow past the motor to operate within specified temperatures. Heat shortens motor life, so cooling is essential. Minimum flow past the motor is easily met when there is the appropriate amount of space between the motor and well casing, and flow into the well casing comes in from below the motor.

Submersible pumps and motors rely on carrying heat away from the motor by forced convection. The water pumped must flow past the motor on its way into the pump intake. **See Table 4** below demonstrating cooling requirements for Grundfos Submersible motors.

Motor Cooling Requirements:
Maximum Water Temperature - Minimum Velocity/Flow Past the Motor

Motor Type	Min. Well Casing or Sleeve Diameter	Minimum Velocity	Minimum Flow	Maximum Temperature of Pumped Liquid	
				Vertical Installation	Horizontal Installation
	Inches (mm)	FT/S (m/s)	GPM (m³/h)	°F (°C)	°F (°C)
MS402 / MS4000	4 (102)	0.00 (0.00)	0.0 (0.0)	86 (30)	Flow Sleeve Recommend
MS402 / MS4000	4 (102)	0.25 (0.08)	1.2 (.27)	104 (40)	104 (40)
MS6000C (T40) (Standard)	6 (152)	0.50 (0.15)	9 (2)	104 (40)	104 (40)
MS6000C (T60) (High Temp)	6 (152)	3.30 (1.00)	30 (6.8)	140 (60)	140 (60)
MMS6	6 (152)	0.15 (0.05)	13 (3)	68 (20)	68 (20)
MMS8000	8 (203)	0.50 (0.15)	25 (5.7)	86 (30)	86 (30)
MMS10000 (175, 200HP)	10 (254)	0.50 (0.15)	55 (12.5)	86 (30)	86 (30)
MMS10000 (250HP)	10 (254)	0.50 (0.15)	41 (9.3)	68 (20)	68 (20)

FT/S = Feet Per Second

Table 4

Submersible motors generate heat that must be dissipated as to not to damage or shorten the life of a motor. There are many factors that contribute to keeping the motor cool within motor specifications:

1. The temperature of the water being pumped.
2. The velocity/flow of water past the motor.
3. Proper phase balance.
4. Proper sizing of liquid end and motor.
5. Proper ramp up and ramp down speeds on VFDs and Soft Starts.
6. Prevention of scale build up on motor.

Excessive ambient water temperature and/or phase unbalanced, reduced velocity/flow rate past the motor requires derating of the load capability of the motor. Derating the load reduces the temperature rise of the motor windings within the limits set by the heat dissipation capacity of the cooling water. For questions on derating motors, please contact Grundfos.

Cooling Techniques:

1. A flow sleeve is required when a submersible motor is in a larger diameter well, an open hole cavern, or a large body of water such as a supply tank, cistern, or pond, where the cooling requirements in the chart above cannot be met. The flow sleeve induces water movement past the motor, increasing cooling.

2. When water enters the well from above the pump or next to the pump inlet, it is drawn down past the pump into the pump intake without flowing past the motor. This lack of cooling water flow will cause the motor to heat up. Solutions include raising the pump and motor to a position above the well intake. This allows the water to flow past the motor, creating the required cooling flow velocity. Installing a sleeve around the pump and motor will also force the water drawn down to come into the bottom of the sleeve and flow past the motor.

Flow Sleeve
In some installations, it is necessary to use a Flow Sleeve to insure that water passes by the motor and properly cooling the motor. In some cases, the Flow Sleeve is used to increase velocity in order to prevent the formation of deposits.

The use of a sleeve should be considered under the following operating scenarios:

1. Top-feeding (cascading) wells: If a well is not cased below the motor, or casing is perforated above the motor, water can be fed directly into the pump without flowing past the motor.

2.Inadequate flow: This can occur if the motor is in a large body of water, if the well casing is much larger than the motor, or if delivery is very low in sump/wet pit tank applications.

3.Corrosion prone wells: If groundwater is aggressive or contains chloride, the corrosion rate will double for every 15°C (56F) increase in temperature between the metallic motor housing and the water. The motor housing is generally 5-15°C (41-56F) warmer than the produced water. A cooling sleeve will therefore reduce the risk of motor corrosion by keeping the exterior motor surface temperature lower during operation.

4.Presence of Iron, Manganese, or Calcium: If the well water contains a significant amount of iron (iron bacteria), manganese, or calcium, these substances will be oxidized and deposited on the motor surface. In the case of low flow past the motor, incrustation build-up forms a heat insulating layer of oxidized minerals, which may result in hot spots in the motor winding insulation. This temperature increase may shorten the life of the motor.

Typical Flow Sleeve Cutaway View:
In addition to factory-made, ready-to-use flow sleeves, it is also possible to make flow sleeves from PVC pipe and stainless steel hose clamps. Both options are effective in cooling a submersible motor when sized properly.

Use the motor cooling requirements in **Table 4** to help size the motor sleeve. Make sure size of Flow Sleeve fits in the well. The motor sleeve is generally of the next nominal diameter of standard pipe larger than the motor or the pump, depending on the sleeve configuration used. The tubular/pipe material can be plastic or thin walled stainless steel (corrosion resistant materials preferred). The cap/top must accommodate the power cable without damage and provide a snug fit, so that only a very small amount of water can be pulled through the top of the sleeve. **The fit should not be completely water tight as ventilation is often required to allow escape of any air or gas that might accumulate.** The sleeve body should be stabilized by self-tapping stainless steel screws installed through the side wall of the Flow Sleeve to prevent rotation and keep the motor centered within the sleeve. The sleeve should extend to a length of 1-2 times the sleeve diameter beyond the bottom of the motor when possible. Sleeves are typically attached immediately above the pump intake or at the pump/column connection. Avoid setting bottom of Flow Sleeve near bottom of well.

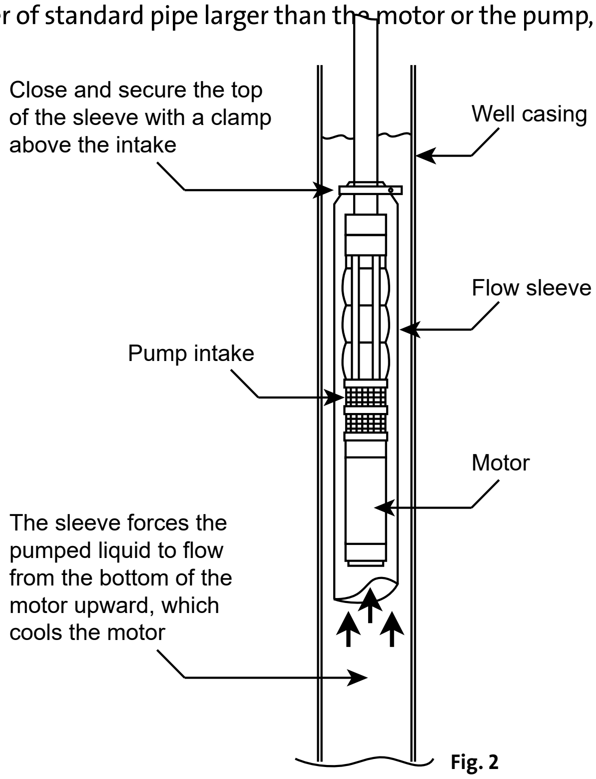


Fig. 2

Table 5 shows the Head Loss from Flow past the motor. Various Motor OD and casing/sleeve combinations will affect the head loss in a water system and should be considered in applications where the pump/motor is marginally submerged and reduced suction conditions exist. Note: This value should be included in a system TDH (Total Dynamic Head) calculation.

Annular Space Head Loss (Hf) from Flow Past Motor (ft. of water)

	Motor Dia. (nominal)	4"	4"	4"	6"	6"	6"	8"	8"
	Casing I.D. Inches (mm)	4.0 (102)	5 (127)	6 (152)	6 (152)	7 (178)	8 (203)	8.1 (206)	10 (254)
GPM	25	0.3	-	-	-	-	-	-	-
	50	1.2	-	-	-	-	-	-	-
	100	4.7	0.3	-	1.7	-	-	-	-
	150	10.2	0.6	0.2	3.7	-	-	-	-
	200	-	1.1	0.4	6.3	0.5	-	6.8	-
	250	-	1.8	0.7	9.6	0.8	-	10.4	-
	300	-	2.5	1.0	13.6	1.2	0.2	14.6	-
	400	-	-	-	23.7	2.0	0.4	24.6	-
	500	-	-	-	-	3.1	0.7	37.3	0.6
	600	-	-	-	-	4.4	1.0	52.2	0.8
	800	-	-	-	-	-	-	-	1.5
	1000	-	-	-	-	-	-	-	2.4

Table 5

Note: The tabulated friction loss values assume maximum motor length for the specified nominal motor size and a smooth casing/sleeve ID and include entry and exit losses.

Fluid Velocity

1) A fluid velocity of 3 fps is generally considered optimum.
2) 0.25 fps is the minimum cooling velocity value.
3) The actual fluid velocity past the motor can be calculated using the formula:

Velocity (past motor) = gpm/2.45 (ID casing)^2 - (OD motor)^2

Note: Casing or shroud ID and motor OD values are in inches, and velocity past the motor is in fps.
Table 5 shows the minimum flow rates, in gpm, for various well diameters and motor sizes.

Minimum Submersible Cooling Flow Requirements

Casing/Sleeve Inside Diameter (Inches)	4" Motor (0.25 fps)	6" Motor (0.5 fps)	8" Motor (0.5 fps)	10" Motor (0.5 fps)
	GPM			
4	1.2	-	-	-
5	7	-	-	-
6	13	9	-	-
7	20	25	-	-
8	30	45	10	-
10	50	90	55	-
12	80	140	110	78
14	110	200	170	140
16	150	280	245	213
18	-	380	335	300

Table 6

Submersible Motor Cooling - Derating Water Temperature

FKM elastomer's (rubber compounds) are recommended any time the normal ambient fluid temperature exceeds 104°F. Allowable % Max. Namplate Amps Derated for Ambient Water Temperature at 0.50 fps

Water Temp.	0 - 3 HP	5 - 15 HP	20 - 40 HP
86°F (30°C)	100%	100%	100%
95°F (35°C)	100%	100%	90%
104°F (40°C)	100%	90%	80%
113°F (45°C)	90%	80%	70%
122°F (50°C)	80%	70%	60%
130°F (55°C)	70%	60%	45%
140°F (60°C)	50%	-	-

Table 7

Note: Derating % is based on an ambient fluid temperature of 30°C (86°F) @ 0.5 fps, consult motor manufacture for specific maximum full-load cooling water temperature without derating. Typical base ambient fluid temperature rating for various manufactures of submersible motors used in the water supply industry range from 77°F (25°C) to 104°F (40°C), with 86°F (30°C) being the most prominent.

Example of Submersible Motor Cooling:

MS 6000C Motor cooling

The motor has cooling chambers at the top and bottom. An efficient internal circulation system help transport the heat from the rotor and bearings via the motor liquid to the outer surface of the motor.

Heat generated in the motor is carried away to the surrounding pumped liquid via the outer surface of the motor.

This is the reason why the temperature of the pumped liquid and its flow velocity past the motor are of vital importance to the life of the motor.

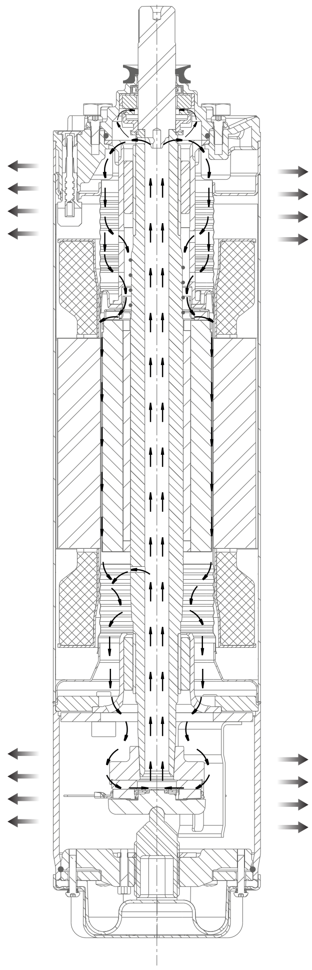


Fig. 3

WARNING!
SERIOUS ELECTRICAL SHOCK CAN OCCUR IF ITEMS ARE NOT GROUNDED PROPERLY TO MEET CODE.

Grounding Control Box and Panel
Reduced risk of electric shock during operation of a pump and motor requires an acceptable ground. Be sure that motor conduit is grounded. The pump is grounded to the service entrance by connecting a copper conductor (at least the size of the circuit supplying the pump) to the grounding screw provided within the wiring compartment.

The National Electrical Code requires that when using a control box, panel or a pressure switch, all grounding terminals are always to be connected to the supply ground. If the circuit has no grounding conductor and no metal conduit from the box to the supply panel, use a wire at least as large as the line conductors and **connect as required by national, state, and local codes** from the grounding terminal to the electrical supply ground.

The control box or control panel must be permanently grounded in accordance with national, state, and local codes.

Always see product Installation and Operations manuals for warnings and proper installation.
Note: The metal well head and metal casing must be grounded.

Grounding Surge Arresters
To perform correctly, above ground surge arresters are required to be grounded from metal to metal, all the way to the lowest draw down water level. Less than truly grounded will allow power surges to cause damage. **See Fig. 5**.

GROUNDING THE ARRESTER TO THE SUPPLY GROUND OR TO A DRIVEN GROUND ROD PROVIDES LITTLE OR NO SURGE PROTECTION FOR THE MOTOR.

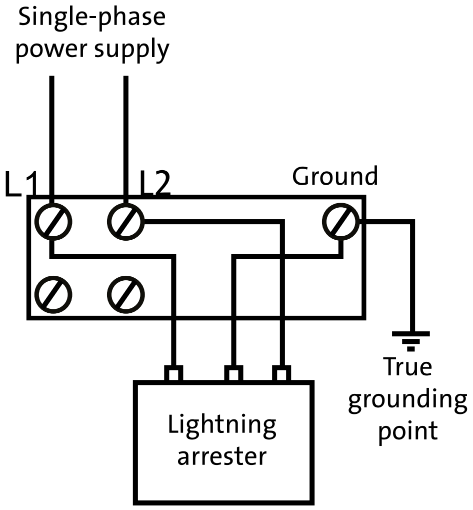


Fig. 4

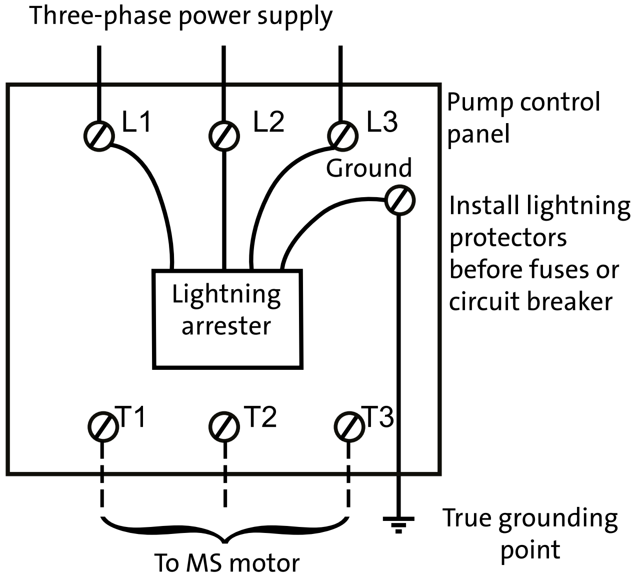


Fig. 5

Equipment and System Grounding
The submersible water system must be grounded from the motor to the service entrance ground, connecting every component in the system in accordance with national, state, and local codes.

Note: Always ground all equipment in accordance with national, state and local codes for where the job is located. If a Surge arrestor is required on a VFD application, it should be installed on the incoming line side of the VFD.

3-Wire Control Boxes
Submersible, single phase, 3-wire motors require the use of a control box. The control box uses capacitors, relays, and in some cases contactors to start and control the submersible 3 wire motor.

CAUTION: The control box and 3-wire motor must match in HP and voltage to operate properly and prevent damage to equipment.

Potential (voltage) Relay
Capacitor start motors need an electrical device to disconnect the start capacitor after the motor starts. This is accomplished thru the use of a potential relay. The potential relay has a normally closed contact. When power is applied, it is sent to both the start winding and run winding simultaneously. As the motor speed increases, the voltage across the relay coil increases until it reaches a pre-determined value. When this coil voltage is reached the contact opens and disconnects the start winding. The motor continues to run on the main winding only. The contact remains open while the motor is running, and resets to the closed position when power is turned off to the motor.

SA-SPM 6 control boxes are used as starting units for single-phase, 3-wire motors ranging from:

- Standard Control Box 0.5 hp to 5 hp (.37 kW to 3.7 kW)
- Standard Control Box and Deluxe Control Box from 1.5 hp to 5 hp (1.1 kW to 3.7 kW)

The Standard Control Box incorporates a motor protective circuit breaker to protect the motor against overload.

The Deluxe Control Box is similar to the Standard Control Box with the addition of a motor contactor.

Control Box Technical Data:
Enclosure class: IP42/NEMA 3R
Ambient Temperature: -4 °F to +140 °F (-20 °C to +60 °C)
Relative humidity: Maximum 95%

SA-SPM6
Single Phase 60Hz Control Boxes For 3-Wire 4" Motors

Type	HP	Volts	Material Number	Material Number For Reference
Standard	1/2	115	98821580	98315240
Standard	1/2	230	98821631	98315251
Standard	3/4	230	98821632	98315252
Standard	1	230	98821633	98315253
Standard	1-1/2	230	98315254	-
Standard	2	230	98315256	-
Standard	3	230	98315258	-
Standard	5	230	98315260	-
Deluxe	1-1/2	230	98315255	-
Deluxe	2	230	98315257	-
Deluxe	3	230	99053534*	98315259
Deluxe	5	230	99053535*	98315261
Deluxe	7-1/2	230	99053536*	-
Deluxe	10	230	99053537*	-
Deluxe	15	230	99053538*	-

* New part numbers coming in 2018. Table 8
* New part numbers with industry standard larger metal enclosure.

SA - SPM6

Operation of MS402 2-wire motor

2-wire submersibe motors do not require a control box for starting. The start up operation of the Grundfos MS402 motor uses both an electronic start circuit and a thermal overload switch in series. When power is applied to the motor it passes through the thermal overload switch and into the start circuit. The electronic start circuit energizes the start winding and the run winding simultaneously to provide the torque required to get the rotor turning. After approximately ½ second, the start winding is disengaged and only the run winding is powered. This one-time start event does not reset until the power is disconnected. It is the role of the thermal overload switch to protect the motor windings against high current. If the motor does not start to rotate before the start winding is disengaged the thermal overload will open after a few seconds to protect the motor. After approximately 20 seconds, the thermal overload switch cools and closes reapplying power to the start circuit and starting the whole process over again.

SINGLE PHASE MOTORS

TWO OR MORE DIFFERENT CABLE SIZES CAN BE USED

Some applications may require the use of different cable sizes to complete the installation.

Examples include occasions when upgrading or replacing existing pump/motor systems where cable is buried and it is not possible to replace. In this case, using the following formula will offer the installer an option of using a different size cable to meet the National Electric Code voltage drop requirement of 1.00. The formula shows that all of the allowed cable voltage drop percentages (%) added together must be less than 1.00 (100%)

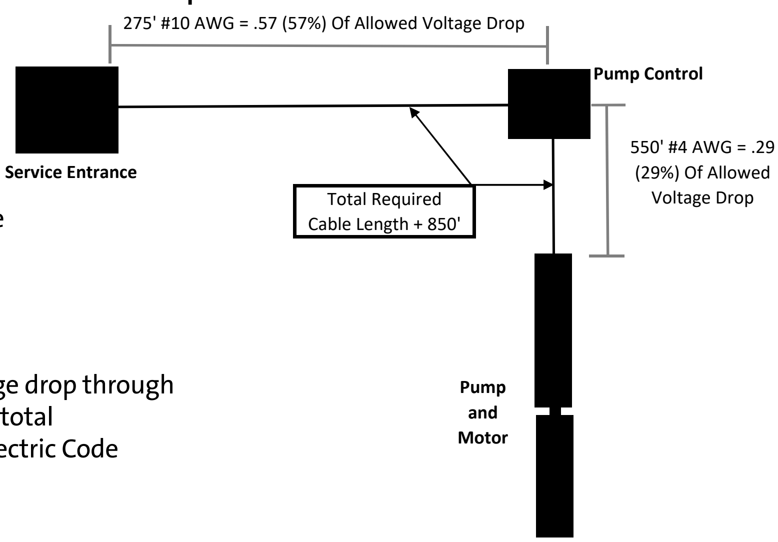
$$\frac{\text{Actual Length}}{\text{Maximum Allowed}} + \frac{\text{Actual Length}}{\text{Maximum Allowed}} = \text{1.00 (100\%) of allowed System Voltage Drop}$$

Example 1:
Motor HP = 1.5 HP 230V 1PH

$$\frac{\text{275' actual of \#10}}{\text{480' Maximum Allowed}} \quad \frac{\text{550' remaining needed of \#4}}{\text{1870' Maximum Allowed}} \quad \text{.86 (86\%) of allowed total system Voltage Drop}$$

= .57 (57%) = .29 (29%) = .86 (86%)

Example:



Total cable length required = 825 ft

Existing cable length = 275 ft (#10 AWG)

Table 9 - 480 ft allowed (#10 AWG)
Formula = 275/480 = .57 (57%) of allowed voltage drop through #10 AWG Cable
Remaining cable length required = 550 ft

Table 9 – 1870 ft (#4 AWG)
Formula = 550/1870 = .29 (29%) of allowed voltage drop through #4 AWG Cable Result = 57% + 29% = .86 (86%) of total system voltage drop allowed per the National Electric Code

60 Hz 75°C (167°F) Maximum Submersible Power Cable Length
Max. Cable Length In Feet (Meters) - Service Entrance to Motor

Motor Rating		AWG copper wire size ft (m)													MCM Copper Wire Size ft (m)				
Volts	HP	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
115	1/2	100 (30)	160 (49)	250 (76)	390 (119)	620 (189)	960 (293)	1190 (363)	1460 (445)	1780 (543)	2160 (658)	2630 (802)	3140 (957)	3770 (1149)	4240 (1292)	4770 (1454)	5320 (1622)	5750 (1753)	6590 (2009)
230	1/2	400 (122)	650 (198)	1020 (311)	1610 (491)	2510 (765)	3880 (1183)	4810 (1466)	5880 (1792)	7170 (2185)	8720 (2658)	10620 (3237)	12660 (3859)	15210 (4636)	17100 (5212)	19260 (5871)	21440 (6535)	23200 (7071)	26600 (8108)
	3/4	300 (91)	480 (146)	760 (232)	1200 (366)	1870 (570)	2890 (881)	3580 (1091)	4370 (1332)	5330 (1625)	6470 (1972)	7870 (2399)	9380 (2859)	11250 (3429)	12640 (3853)	14220 (4334)	15810 (4819)	17090 (5209)	19570 (5965)
	1	250 (76)	400 (122)	630 (192)	990 (302)	1540 (469)	2380 (725)	2960 (902)	3610 (1100)	4410 (1344)	5360 (1634)	6520 (1987)	7780 (2371)	9350 (2850)	10510 (3204)	11840 (3609)	13180 (4017)	14260 (4347)	16350 (4984)
	1-1/2	190 (58)	310 (94)	480 (146)	770 (235)	1200 (366)	1870 (570)	2320 (707)	2850 (869)	3500 (1067)	4280 (1305)	5240 (1597)	6300 (1920)	7620 (2323)	8630 (2630)	9810 (2990)	10980 (3347)	11960 (3645)	13860 (4225)
	2	150 (46)	250 (76)	390 (119)	620 (189)	970 (296)	1530 (466)	1910 (582)	2360 (719)	2930 (893)	3620 (1103)	4480 (1366)	5470 (1667)	6700 (2042)	770 (235)	8890 (2710)	10080 (3072)	11130 (3392)	13170 (4014)
	3	**120* (37)**	190 (58)	300 (91)	470 (143)	750 (229)	1190 (363)	1490 (454)	1850 (564)	2320 (707)	2890 (881)	3610 (1100)	4470 (1362)	5550 (1692)	6450 (1966)	7580 (2310)	8690 (2649)	9740 (2969)	11770 (3588)
	5	-	**110* (34*)**	180 (55)	280 (85)	450 (137)	710 (216)	890 (271)	1110 (338)	1390 (424)	1740 (530)	2170 (661)	2680 (817)	3330 (1015)	3870 (1180)	4550 (1387)	5210 (1588)	5840 (1780)	7060 (2152)
	7-1/2	-	-	**120* (37*)**	200 (61)	310 (94)	490 (149)	610 (186)	750 (229)	930 (283)	1140 (347)	1410 (430)	1720 (524)	2100 (640)	2400 (732)	2790 (850)	3120 (951)	3430 (1046)	4040 (1231)
	10	-	-	-	**160* (49*)**	250 (76)	390 (119)	490 (149)	600 (183)	750 (229)	930 (283)	1160 (354)	1430 (436)	1760 (536)	2030 (619)	2370 (722)	2700 (823)	3000 (914)	3590 (1094)
	15	-	-	-	-	**170* (52*)**	270 (82)	340 (104)	430 (131)	530 (162)	660 (201)	820 (250)	1020 (311)	1260 (384)	1460 (445)	1700 (518)	1940 (591)	2170 (661)	2610 (796)

Table 9

Note: ***(for all cable selection tables)***

Bold and * Indicates conductor only. (Not jacketed)
No * indicates both jacketed cable and single conductor cables.
1. Table based on copper wire. If aluminum wire is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size. Seek Aluminum wire industry for cable selection table.
2. The portion of the total cable which is between the service entrance and a motor starter/controller should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Table based on a maintaining motor terminal voltage at 95% of service entrance voltage, running at maximum nameplate amperes. In general, voltage drop should be maintained at 3V/100 ft. or less.
4. One foot = .305 meter (1 meter = 3.28 feet)

4" 2-Wire Single Phase Motors - Control Box Not Required

Motor Type	HP	Kw	Volts	Service Factor	Full Load				Service Factor (Max. Load)				Locked Rotor	KVA Code	Line-to-Line Resistance (Ohm)		Max. Thrust	RPM
					Amps	Watts*	Power Fact.	Eff. %	Amps	Watts*	Power Fact.	Eff. %	Amps**		Black-Yellow	Red-Yellow		
MS402	1/2	0.37	115	1.60	9.5	675	0.67	55.0	12.0	1076	0.78	62	82.8	R	1.1 - 1.3		900	3450
	1/2	0.37	230	1.60	4.5	646	0.63	57.7	6.0	1049	0.76	62	37.2	R	4.0 - 4.8			
	3/4	0.55		1.50	6.9	994	0.63	56.3	8.4	1449	0.75	62	51.2	N	3.2 - 3.8			
	1	0.75		1.40	8.8	1260	0.67	59.7	9.8	1848	0.82	63	55.9	M	2.5 - 3.1			
	1 1/2	1.10		1.30	11.6	1760	0.70	62.7	13.1	2561	0.85	64	81.2	L	1.7 - 2.1			

4" 3-Wire Single Phase Motors - Control Box Required

Motor Type	HP	Kw	Volts	Service Factor	Full Load*				Service Factor (Max. Load)				Locked Rotor	KVA Code	Line-to-Line Resistance (Ohm)		Max. Thrust	RPM
					Amps	Watts**	Power Fact.	Eff. %	Amps	Watts**	Power Fact.	Eff. %	Amps***		Black-Yellow	Red-Yellow		
MS402	1/2	0.37	115	1.60	10.0	992	0.74	37.6	12.0	1049	0.73	61	44.4	L	0.9 - 1.1	1.9 - 2.4	900	3450
	1/2	0.37	230	1.60	5.6	968	0.75	38.2	6.0	1049	0.76	62	24.6	L	4.0 - 4.9	15.8 - 19.6		
	3/4	0.55		1.50	8.4	1410	0.76	39.7	8.4	1449	0.75	62	34.4	L	3.2 - 3.9	14 - 17.2		
	1	0.75		1.40	9.0	1662	0.81	44.9	9.8	1848	0.82	63	42.1	K	2.6 - 3.1	10.3 - 12.5		
	1 1/2	1.10		1.30	10.7	2169	0.89	51.6	11.6	2375	0.89	69	58.0	H	1.9 - 2.3	7.8 - 9.6		
MS4000	2	1.50	230	1.25	13.1	2582	0.86	57.8	13.2	2611	0.86	72	55.4	G	1.5 - 1.8	3.4 - 4.1	1500	3450
	3	2.20		1.15	16.8	3601	0.93	62.1	17.0	3636	0.93	74	103.7	F	1.2 - 1.4	2.5 - 3.0		
	5	3.70		1.15	25.7	5645	0.96	66.0	27.5	5819	0.92	77	110.0	F	0.65 - 0.85	1.7 - 2.1		

*Calculated Value (Voltage x Current x Cos F)

**Calculated Value (Full Load current x Locked Rotor Current %)

Table 10

4" 2-Wire Single Phase Motors - Control Box Not Required

HP	kW	Volt	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC)		
				Standard Fuse	Time Delay Fuse	Circuit Breaker
1/2	0.37	115	12.0	35	20	30
1/2	0.37	230	6.0	20	10	15
3/4	0.55		8.4	25	15	20
1	0.75		9.8	30	20	25
1 1/2	1.10		11.6	35	20	30

4" 3-Wire Single Phase Motors - Control Box Required

HP	kW	Volt	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC)		
				Standard Fuse	Time Delay Fuse	Circuit Breaker
1/2	0.37	115	12.0	35	20	30
1/2	0.37	230	6.0	20	10	15
3/4	0.55		8.4	25	15	20
1	0.75		9.8	30	20	25
1 1/2	1.10		11.6	35	20	30
2	1.50		13.2	35	20	30
3	2.20		17.0	50	30	45
5	3.70		27.5	80	45	75

Table 11

Buck-Boost Transformers

A convenient and low cost method to adjust available power supply voltage is the utilization of a buck-boost transformer.

Common usage is to buck (lower) or boost (raise) the supply voltage, depending on application manufacturer, usually 5 to 27%. A common example would be to raise 208 supply voltage to 230 volts to match single-phase submersible motor and controls.

When selecting a buck-boost transformer you will need the following information: 1) Input line voltage, 2) Voltage required for the load, 3) kVA or Amperage rating of the load, 4) Frequency, 5) Number of phases, 6) Type of electrical connection; Delta or Wye.

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

Table 12

60 Hz 75°C (167°F) Maximum Submersible Power Cable Length
Max. Cable Length In Feet (Meters) - Service Entrance to Motor

Motor Rating		AWG copper wire size ft (m)													MCM Copper Wire Size ft (m)				
Volts	HP	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
200-208	1/2	710 (216)	1140 (347)	1800 (549)	2840 (866)	4420 (1347)	-	-	-	-	-	-	-	-	-	-	-	-	-
	3/4	510 (155)	810 (245)	1280 (390)	2030 (619)	3160 (963)	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	430 (131)	690 (210)	1080 (329)	1710 (521)	2670 (814)	4140 (1262)	5140 (1567)	-	-	-	-	-	-	-	-	-	-	-
	1-1/2	310 (94)	500 (152)	790 (241)	1260 (384)	1960 (597)	3050 (930)	3780 (1152)	-	-	-	-	-	-	-	-	-	-	-
	2	240 (73)	390 (119)	610 (186)	970 (296)	1520 (463)	2360 (719)	2940 (896)	3610 (1100)	4430 (1350)	5420 (1652)	-	-	-	-	-	-	-	-
	3	180 (55)	290 (88)	470 (143)	740 (226)	1160 (354)	1810 (552)	2250 (686)	2760 (841)	3390 (1033)	4130 (1259)	-	-	-	-	-	-	-	-
	5	**110* (34*)**	170 (52)	280 (85)	440 (134)	690 (210)	1080 (329)	1350 (411)	1660 (506)	2040 (622)	2490 (759)	3050 (930)	3670 (1119)	4440 (1353)	5030 (1533)	-	-	-	-
	7-1/2	-	-	200 (61)	310 (94)	490 (149)	770 (235)	960 (293)	1180 (360)	1450 (442)	1770 (539)	2170 (661)	2600 (792)	3150 (960)	3560 (1085)	-	-	-	-
	10	-	-	-	**230* (70*)**	370 (113)	570 (174)	720 (219)	880 (268)	1090 (332)	1330 (405)	1640 (500)	1970 (600)	2390 (728)	2720 (829)	3100 (945)	3480 (1061)	3800 (1158)	4420 (1347)
	15	-	-	-	**160* (49*)**	**250* (76*)**	390 (119)	490 (149)	600 (183)	740 (226)	910 (277)	1110 (338)	1340 (408)	1630 (497)	1850 (564)	2100 (640)	2350 (716)	2570 (783)	2980 (908)
	20	-	-	-	-	**190* (58*)**	**300* (91*)**	380 (116)	460 (140)	570 (174)	700 (213)	860 (262)	1050 (320)	1270 (387)	1440 (439)	1650 (503)	1850 (564)	2020 (616)	2360 (719)
	25	-	-	-	-	-	**240* (73*)**	**300* (91*)**	**370* (113*)**	460 (140)	570 (174)	700 (213)	840 (256)	1030 (314)	1170 (357)	1330 (405)	1500 (457)	1640 (500)	1900 (579)
	30	-	-	-	-	-	-	**250* (76*)**	**310* (94*)**	**380* (116*)**	470 (143)	580 (177)	700 (213)	850 (259)	970 (296)	1110 (338)	1250 (381)	1360 (415)	1590 (485)

Table 13

Note: ***(for all cable selection tables)***

Bold and * Indicates conductor only. (Not jacketed)
No * indicates both jacketed cable and single conductor cables.
1. Table based on copper wire. If aluminum wire is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size. Seek Aluminum wire industry for cable selection table.
2. The portion of the total cable which is between the service entrance and a motor starter/controller should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Table based on a maintaining motor terminal voltage at 95% of service entrance voltage, running at maximum nameplate amperes. In general, voltage drop should be maintained at 3V/100 ft. or less.
4. One foot = .305 meter (1 meter = 3.28 feet)

60 Hz 75°C (167°F) Maximum Submersible Power Cable Length
Max. Cable Length In Feet (Meters) - Service Entrance to Motor

Motor Rating		AWG copper wire size ft (m)													MCM Copper Wire Size ft (m)				
Volts	HP	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
230	1/2	930 (283)	1490 (454)	2350 (716)	3700 (1128)	5760 (1756)	8910 (2716)	-	-	-	-	-	-	-	-	-	-	-	-
	3/4	670 (204)	1080 (329)	1700 (518)	2580 (786)	4190 (1277)	6490 (1978)	8060 (2457)	9860 (3005)	-	-	-	-	-	-	-	-	-	-
	1	560 (171)	910 (277)	1430 (436)	2260 (689)	3520 (1073)	5460 (1664)	6780 (2067)	8290 (2527)	-	-	-	-	-	-	-	-	-	-
	1-1/2	420 (128)	670 (204)	1060 (323)	1670 (509)	2610 (796)	4050 (1234)	5030 (1533)	6160 (1878)	7530 (2295)	9170 (2795)	-	-	-	-	-	-	-	-
	2	320 (98)	510 (155)	810 (247)	1280 (390)	2010 (613)	3130 (954)	3890 (1186)	4770 (1454)	5860 (1786)	7170 (2185)	8780 (2676)	-	-	-	-	-	-	-
	3	240 (73)	390 (119)	620 (189)	990 (302)	1540 (469)	2400 (732)	2980 (908)	3660 (1116)	4480 (1366)	5470 (1667)	6690 (2039)	8020 (2444)	9680 (2950)	-	-	-	-	-
	5	**140* (43*)**	230 (70)	370 (113)	590 (180)	920 (280)	1430 (436)	1790 (546)	2190 (668)	2690 (820)	3290 (1003)	4030 (1228)	4850 (1478)	5870 (1789)	6650 2027	7560 (2304)	8460 (2579)	9220 (2810)	-
	7-1/2	-	**160* (49*)**	260 (79)	420 (128)	650 (198)	1020 (311)	1270 (387)	1560 (475)	1920 (585)	2340 (713)	2870 (875)	3440 (1049)	4160 (1268)	4710 (1436)	5340 (1628)	5970 (1820)	6500 (1981)	7510 (2289)
	10	-	-	**190* (58*)**	310 (94)	490 (149)	760 (232)	950 (290)	1170 (357)	1440 (439)	1760 (536)	2160 (658)	2610 (796)	3160 (963)	3590 (1094)	4100 (1250)	4600 (1403)	5020 (1530)	5840 (1780)
	15	-	-	-	**210* (64*)**	330 (101)	520 (158)	650 (198)	800 (244)	980 (299)	1200 (366)	1470 (448)	1780 (543)	2150 (655)	2440 (744)	2780 (847)	3110 (948)	3400 (1036)	3940 (1201)
	20	-	-	-	-	**250* (76*)**	400 (122)	500 (152)	610 (186)	760 (232)	930 (283)	1140 (347)	1380 (421)	1680 (512)	1910 (582)	2180 (665)	2450 (747)	2680 (817)	3120 (951)
	25	-	-	-	-	-	**320* (98*)**	400 (122)	500 (152)	610 (186)	750 (229)	920 (280)	1120 (341)	1360 (415)	1540 (469)	1760 (537)	1980 (604)	2160 (658)	2520 (768)
	30	-	-	-	-	-	**260* (79*)**	**330* (101*)**	**410* (125*)**	510 (155)	620 (189)	760 (232)	930 (283)	1130 (344)	1280 (390	1470 (448)	1650 (503)	1800 (549)	2110 (643)

Table 14

Note: ***(for all cable selection tables)***

Bold and * Indicates conductor only. (Not jacketed)
No * indicates both jacketed cable and single conductor cables.
1. Table based on copper wire. If aluminum wire is used, multiply lengths by 0.5. Maximum allowable length of aluminum is considerably shorter than copper wire of same size.
2. The portion of the total cable which is between the service entrance and a motor starter/controller should not exceed 25% of the total maximum length to assure reliable starter operation. Single-phase control boxes may be connected at any point of the total cable length.
3. Table based on a maintaining motor terminal voltage at 95% of service entrance voltage, running at maximum nameplate amperes. In general, voltage drop should be maintained at 3V/100 ft. or less.
4. One foot = .305 meter (1 meter = 3.28 feet)

60 Hz 75°C (167°F) Maximum Submersible Power Cable Length
Max. Cable Length In Feet (Meters) - Service Entrance to Motor

Motor Rating		AWG copper wire size ft (m)													MCM Copper Wire Size ft (m)				
Volts	HP	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
460	1/2	3770 (1149)	6020 (1835)	9460 (2883)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3/4	2730 (832)	4350 (1326)	6850 (2088)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	2300 (701)	3670 (1119)	5770 (1759)	9070 (2765)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1-1/2	1700 (518)	2710 (826)	4270 (1301)	6730 (2051)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	1300 (396)	2070 (631)	3270 (997)	5150 (1570)	8050 (2454)	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	1000 (305)	1600 (488)	2520 (768)	3970 (1210)	6200 (1890)	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	590 (180)	950 (290)	1500 (457)	2360 (719)	3700 (1128)	5750 (1753)	-	-	-	-	-	-	-	-	-	-	-	-
	7-1/2	420 (128)	680 (207)	1070 (326)	1690 (515)	2640 (805)	4100 (1250)	5100 (1554)	6260 (1908)	7680 (2341)	-	-	-	-	-	-	-	-	-
	10	310 (94)	500 (152)	790 (241)	1250 (381)	1960 (597)	3050 (930)	3800 (1158)	4680 (1426)	5750 (1753)	7050 (2149)	-	-	-	-	-	-	-	-
	15	-	**340* (104*)**	540 (165)	850 (259)	1340 (408)	2090 (637)	2600 (792)	3200 (975)	3930 (1198)	4810 (1466)	5900 (1798)	7110 (2167)	-	-	-	-	-	-
	20	-	-	410 (125)	650 (198)	1030 (314)	1610 (491)	2000 (610)	2470 753)	3040 (927)	3730 (1137)	4580 (1396)	5530 (1686)	-	-	-	-	-	-
	25	-	-	**330* (101*)**	530 (162)	830 (253)	1300 (396)	1620 (494)	1990 (607)	2450 (747)	3010 (917)	3700 (1128)	4470 (1362)	5430 (1655)	-	-	-	-	-
	30	-	-	**270* (82*)**	430 (131)	680 (207)	1070 (326)	1330 (405)	1640 (500)	2030 (619)	2490 (759)	3060 (933)	3700 (1128)	4500 (1372)	5130 (1564)	5860 (1786)	-	-	-
	40	-	-	-	**320* (98*)**	**500* (152*)**	790 (241)	980 (299)	1210 (369)	1490 (454)	1830 (558)	2250 (686)	2710 (826)	3290 (1003)	3730 (1137)	4250 (1295)	-	-	-
	50	-	-	-	-	**410* (125*)**	640 (195)	800 (244)	980 (299)	1210 (369)	1480 (451)	1810 (552)	2190 (668)	2650 (808)	3010 (918)	3420 (1042)	3830 (1167)	4180 (1274)	4850 (1478)
	60	-	-	-	-	-	**540* (165*)**	**670* (204*)**	830 (253)	1020 (311)	1250 (381)	1540 (469)	1850 (564)	2240 (683)	2540 (774)	2890 (881)	3240 (988)	3540 (1079)	4100 (1250)
	75	-	-	-	-	-	**440* (134*)**	**550* (168*)**	**680* (207*)**	840 (256)	1030 (314)	1260 (384)	1520 (463)	1850 (564)	2100 (640)	2400 (732)	2700 (823)	2950 (899)	3440 (1049)
	100	-	-	-	-	-	-	-	**500* (152*)**	**620* (189*)**	**760* (232*)**	940 (287)	1130 (344)	1380 (421)	1560 (476)	1790 (546)	2010 (613)	2190 (668)	2550 (777)
	125	-	-	-	-	-	-	-	-	-	**600* (183*)**	**740* (226*)**	**890* (271*)**	1000 (305)	1220 (372)	1390 (424)	1560 (476)	1700 (518)	1960 (597)
	150	-	-	-	-	-	-	-	-	-	-	**630* (192*)**	**760* (232*)**	**920* (280*)**	1050 (320)	1190 363)	1340 (408)	1460 (445)	1690 (515)
	175	-	-	-	-	-	-	-	-	-	-	-	**670* (204*)**	**810* (247*)**	**930* (284)**	1060 (323)	1190 (363)	1300 (396)	1510 (460)
	200	-	-	-	-	-	-	-	-	-	-	-	**590* (180*)**	**710* (216*)**	**810* (247)**	**920* (280)**	1030 (314)	1130 (344)	1310 (399)
	250	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	760 (232)	865 (264)

Table 15

GRUNDFOS

60 Hz 75°C (167°F) Maximum Submersible Power Cable Length
Max. Cable Length In Feet (Meters) - Service Entrance to Motor

Motor Rating		AWG copper wire size ft (m)													MCM Copper Wire Size ft (m)				
Volts	HP	14	12	10	8	6	4	3	2	1	0	00	000	0000	250	300	350	400	500
575	1/2	5900 (1798)	9410 (2868)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3/4	4270 (1301)	6810 (2076)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	3630 (1106)	5800 (1768)	9120 (2780)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1-1/2	2620 (799)	4180 (1274)	6580 2006)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	2030 (619)	3250 (991)	5110 (1558)	8060 (2457)	-	-	-	-	-		-	-	-	-	-	-	-	-
	3	1580 (482)	2530 (771)	3980 (1213)	6270 (1911)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	920 (280)	1480 (451)	2330 (710)	3680 (1122)	5750 (1753)	-	-	-	-	-	-	-	-	-	-	-	-	-
	7-1/2	660 (201)	1060 (323)	1680 (512)	2650 (808)	4150 (1265)	-	-	-	-	-	-	-	-	-	-	-	-	-
	10	490 (149)	780 (238)	1240 (378)	1950 (594)	3060 (933)	4770 (1454)	5940 (1811)	-	-	-	-	-	-	-	-	-	-	-
	15	**330* (101*)**	530 (162)	850 (259)	1340 (408)	2090 (637)	3260 (994)	4060 (1237)	-	-	-	-	-	-	-	-	-	-	-
	20	-	**410* (125*)**	650 (198)	1030 (314)	1610 (491)	2520 (768)	3140 (957)	3860 (1177)	4760 (1451)	5830 (1777)	-	-	-	-	-	-	-	-
	25	-	-	520 (158)	830 (253)	1300 (396)	2030 (619)	2530 (771)	3110 (948)	3840 (1170)	4710 (1436)	-	-	-	-	-	-	-	-
	30	-	-	**430* (131*)**	680 (207)	1070 (326)	1670 (509)	2080 (634)	2560 (780)	3160 (963)	3880 (1183)	4770 (1454)	5780 (1762)	7030 (2143)	8000 (2438)	-	-	-	-
	40	-	-	-	**500* (152*)**	790 (241)	1240 (378)	1540 (469)	1900 (579)	2330 (710)	2860 (872)	3510 (1070)	4230 (1289)	5140 (1567)	5830 (1777)	-	-	-	-
	50	-	-	-	**410* (125*)**	**640* (195*)**	1000 (305)	1250 (381)	1540 (469)	1890 (576)	2310 (704)	2840 (866)	3420 (1042)	4140 (1262)	4700 (1433)	5340 (1628)	5990 (1826)	6530 (1990)	7580 (2310)
	60	-	-	-	-	**540* (165*)**	850 (259)	1060 (323)	1300 (396)	1600 (488)	1960 (597)	2400 (732)	2890 (881)	3500 (1067)	3970 (1210)	4520 (1378)	5070 (1545)	5530 (1686)	6410 (1954)
	75	-	-	-	-	-	**690* (210*)**	860 (262)	1060 (323)	1310 (399)	1600 (488)	1970 (600)	2380 (725)	2890 (881)	3290 (1003)	3750 (1143)	4220 (1286)	4610 (1405)	5370 (1637)
	100	-	-	-	-	-	-	**640* (195*)**	**790* (241*)**	970 (296)	1190 (363)	1460 (445)	1770 (539)	2150 (655)	2440 (744)	2790 (850)	3140 (957)	3430 (1046)	3990 (1216)
	125	-	-	-	-	-	-	-	**630* (192*)**	**770* (235*)**	950 (290)	1160 (354)	1400 (427)	1690 (515)	1920 (585)	2180 (665)	2440 (744)	2650 (808)	3070 (936)
	150	-	-	-	-	-	-	-		**660* (202*)**	**800* (244*)**	**990* (302*)**	1190 (363)	1440 (439)	1630 (497)	1860 (567)	2080 (634)	2270 (692)	2640 (805)
	175	-	-	-	-	-	-	-	-	-	**700* (214*)**	**870* (265*)**	**1050* (320*)**	1270 (387)	1450 (442)	1650 (503)	1860 (567)	2030 (619)	2360 (719)
	200	-	-	-	-	-	-	-	-	-	-	**760* (232*)**	**920* (280*)**	**1110* (338*)**	1260 (384)	1440 (439)	1620 (494)	1760 (537)	2050 (625)

Table 16

4” Three Phase 60 Hz Motors

Motor Type	HP	Kw	Volts	Service Factor	Full Load				Service Factor (Max. Load)				Locked Rotor	KVA Code	Line-to-Line Resistance Min. / Max. (Ω Ohms)		Max. Thrust	RPM
					Amps	Watts*	Power Fact.	Eff. %	Amps	Watts*	Power Fact.	Eff. %	Amps**					
MS402	1/2	0.37	208	1.60	3.3	623	0.53	59.4	3.5	908	0.72	67	16.1	N	5.9	7.3	900	3450
			230		3.0	625	0.53	59.2	3.2	904			14.5		7.3	8.9		
			460		1.5	625	0.53	59.2	1.6	918			7.4		28.8	35.2		
			575		1.2	618	0.53	59.5	1.3	896			5.8		45.9	56.1		
	3/4	0.55	208	1.50	4.6	878	0.53	62.7	5.1	1286	0.70	69	23.5	N	4.1	5.1	900	3450
			230		4.2	883	0.53	62.3	4.6	1283			21.2		5.1	6.3		
			460		2.1	878	0.53	62.6	2.3	1283			10.6		20.9	25.5		
			575		1.7	881	0.53	62.4	1.9	1290			8.5		31.7	38.7		
	1	0.75	208	1.40	4.9	1105	0.63	67.4	6.0	1578	0.73	70	28.8	M	3.3	4.1	900	3450
			230		4.6	1129	0.62	66.3	5.4	1570			25.9		4.2	5.2		
			460		2.3	1131	0.62	66.3	2.7	1570			13.0		17.1	20.9		
			575		1.8	1130	0.62	66.3	2.2	1563			10.3		26.3	32.1		
	1-1/2	1.10	208	1.30	6.6	1581	0.67	70.1	8.1	2101	0.72	75	40.5	M	2.4	2.9	900	3450
			230		5.8	1571	0.68	70.8	7.3	2094			37.2		2.8	3.4		
			460		2.9	1559	0.67	71.0	3.7	2094			18.6		11.3	13.8		
			575		2.3	1560	0.69	70.7	2.9	2080			14.5		18.4	22.4		
	2	1.50	208	1.25	8.1	2043	0.70	73.2	9.6	2594	0.75	76	51.8	L	1.7	2.1	900	3450
			230		7.5	2062	0.69	72.8	8.7	2599			47.0		2.1	2.5		
			460		3.7	2056	0.69	72.7	4.4	2599			23.5		8.3	10.1		
			575		3.1	2071	0.68	72.7	3.5	2614			19.3		12.8	15.6		
MS4000	3	2.20	208	1.15	9.9	2996	0.84	72.6	11.9	3644	0.85	73	61.9	J	1.8	2.2	1500	3415
			230		10.4	3054	0.74	71.6	11.6	3466	0.75		60.3		1.8	2.2		3460
			440		5.0	3010	0.79	73.6	5.7	3531	0.82		28.8		7.4	9.0		3440
			460		5.2	3042	0.74	72.7	5.8	3604	0.78		30.7		7.4	9.0		3460
			575		3.9	3014	0.77	73.5	4.7	3520	0.76		24.2		11.7	14.3		3470
	5	3.70	208	1.15	15.7	4864	0.86	76.0	18.6	5830	0.87	77	106.0	K	1.0	1.2	1500	3425
			230		15.0	4840	0.81	76.7	17.4	5407	0.78		102.7		1.0	1.2		3470
			440		7.5	4820	0.84	76.5	8.7	5472	0.83		47.6	J	4.2	5.1		3460
			460		7.5	4814	0.81	76.6	8.7	5513	0.80		51.0		4.2	5.2		3470
			575		6.1	4617	0.76	80.5	6.9	5498	0.80		40.7		6.4	7.8		3470
	7-1/2	5.50	208	1.15	22.8	7146	0.87	76.8	27.0	8657	0.89	81	137.7	I	0.7	0.9	1500	3415
			230		21.5	7023	0.82	78.0	25.0	8167	0.82		155.0		0.7	0.9		3460
			440		10.8	6996	0.85	78.0	12.8	8487	0.87		73.0		3.0	3.6		3440
			460		10.6	6925	0.82	78.3	12.6	8232	0.82		78.1		3.0	3.6		3460
			575		8.7	6876	0.79	81.4	10.0	8167	0.82		62.0		4.5	5.5		3460
	10	7.50	440	1.15	15.1	9667	0.84	78.0	18.0	11386	0.83	81	108.0	J	2.1	2.6	1500	3420
			460		15.0	9561	0.80	78.0	18.6	11856	0.80		119.0		2.2	2.6		3460
			575		12.5	9212	0.74	81.0	14.4	11330	0.79		90.7		3.3	4.0		3440

*Calculated Value (Voltage x Current x Cos F)

**Calculated Value (Full Load current x Locked Rotor Current %)

Table 17

4" Three Phase 60 Hz Motors

HP	kW	Volt	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC) Standard Fuse	Time Delay Fuse	Circuit Breaker	NEMA Starter Size	IEC Starter Size
1/2	0.37	208	3.5	10	6	8	00	A
		230	3.2	8	5	6	00	A
		460	1.6	4	3	3	00	A
		575	1.3	3	2	2	00	A
3/4	0.55	208	5.1	15	8	10	00	A
		230	4.6	10	8	8	00	A
		460	2.3	6	4	5	00	A
		575	1.9	5	3	4	00	A
1	0.75	208	6.0	15	10	15	00	A
		230	5.4	15	8	10	00	A
		460	2.7	8	4	8	00	A
		575	2.2	6	3	5	00	A
1-1/2	1.10	208	8.1	20	14	15	00	A
		230	7.3	15	12	10	00	A
		460	3.7	10	6	8	00	A
		575	2.9	8	5	6	00	A
2	1.50	208	9.6	30	20	25	0	B
		230	8.7	25	15	20	0	B
		460	4.4	12	8	10	00	A
		575	3.5	10	6	8	00	A
3	2.2	208	11.9	35	25	30	0	C
		230	11.6	30	20	25	0	C
		440	5.7	20	10	15	0	A
		460	5.8	20	10	15	0	A
		575	4.7	15	8	10	0	A
5	3.7	208	18.6	50	35	40	1	D
		230	17.4	50	30	40	1	D
		440	8.7	25	15	20	0	B
		460	8.7	25	15	20	0	B
		575	6.9	20	10	15	0	A
7-1/2	5.5	208	27.0	80	45	64	1	E
		230	25.0	75	40	60	1	E
		440	12.8	35	20	25	1	C
		460	12.6	35	20	25	1	C
		575	10.0	30	15	25	1	B
10	7.5	440	18.0	50	30	40	1	D
		460	18.6	50	30	40	1	D
		575	14.4	40	25	30	1	C

Table 18

Notes:
The Fuses and Circuit Breakers were calculated from the NEC table 430.52.
Starters and overloads should always be sized by a licensed electrician that is familiar with local codes and standards.
The overloads for submersible motors should be Class 10 Quick Trip ambient compensated.

6" Three Phase 60 Hz Motors

Motor Type	Hp	kW	Volts	Service Factor	Full Load				Service Factor (Max. Load)				Locked Rotor	KVA Code	Line-to-Line Resistance Min. / Max. (Ω Ohms)		Thrust Bearing (LBS.)	RPM
					Amps	Watts*	Power Fact.	Eff. %	Amps	Watts*	Power Fact.	Eff. %	Amps**		Min.	Max.		
MS6000C	7-1/2	5.5	208	1.15	24.2	7149	0.82	80.2	27.5	8223	0.83	79.4	114.0	H	0.6	0.7	6070	3450
			230		23.4	7178	0.77	80.6	26.0	8286	0.80	80.8	130.0					3480
			440		11.6	7161	0.81	80.6	13.2	8249	0.82	80.4	61.0	J	2.2	2.7		3470
			460		11.6	7117	0.77	80.6	13.0	8286	0.80	80.8	64.5					3480
			480		12.0	7283	0.73	80.2	13.0	8322	0.77	80.7	68.0					3490
			575		9.3	7186	0.78	80.6	10.2	8228	0.81	80.8	51.0	H	3.5	4.3		3480
	10	7.5	208	1.15	32.0	9684	0.84	80.5	37.5	11483	0.85	79.2	126.0	G	0.4	0.5	6070	3420
			230		30.0	9680	0.81	81.7	33.5	11077	0.83	81.5	142.0					3470
			440		15.2	9615	0.83	81.5	17.4	11139	0.84	81.0	67.5		1.7	2.0		3450
			460		15.0	9680	0.81	81.8	16.8	11110	0.83	81.7	71.0					3470
			480		15.0	9602	0.77	81.8	16.6	11041	0.80	82.0	75.0					3480
			575		12.0	9680	0.81	81.4	13.4	11077	0.83	81.2	56.5		2.7	3.3		3470
	15	11.0	208	1.15	46.5	14072	0.84	82.1	53.5	16383	0.85	81.1	198.0	G	0.3	0.3	6070	3430
			230		44.5	14005	0.79	83.0	49.5	16170	0.82	82.9	224.0					3470
			440		22.0	13916	0.83	82.8	25.0	16004	0.84	82.1	100.0	H	1.1	1.3		3450
			460		21.6	13940	0.81	83.1	24.4	16136	0.83	82.8	106.0					3470
			480		21.6	13828	0.77	83.1	24.0	15963	0.80	83.2	112.0					3480
			575		17.2	13875	0.81	83.0	19.4	16036	0.83	82.7	84.0	G	1.7	2.1		3460
	20	15.0	208	1.15	61.5	19054	0.86	82.7	71.5	22153	0.86	81.5	310.0	H	0.2	0.2	6070	3430
			230		57.5	18783	0.82	84.0	65.0	21751	0.84	83.7	350.0					3470
			440		29.0	18565	0.84	83.7	33.5	21701	0.85	82.9	166.0	J	0.7	0.9		3450
			460		29.0	18947	0.82	84.0	32.5	21751	0.84	83.7	176.0					3470
			480		29.0	18806	0.78	83.9	32.0	21549	0.81	83.9	186.0					3480
			575		23.4	18877	0.81	83.8	26.0	21492	0.83	83.5	144.0		1.1	1.4		
	25	18.5	208	1.15	75.0	23237	0.86	83.4	87.0	26955	0.86	82.3	395.0	J	0.2	0.2	6070	3430
			230		71.0	22910	0.81	84.6	80.0	26452	0.83	84.3	445.0					3480
			440		36.0	23046	0.84	84.3	41.0	26559	0.85	83.6	212.0		0.6	0.7		3460
			460		35.5	22910	0.81	84.6	40.0	26452	0.83	84.3	224.0					3480
			480		36.0	23046	0.77	84.3	39.5	26272	0.80	84.4	236.0					3490
			575		28.5	23275	0.82	84.0	32.0	26452	0.83	83.7	180.0		0.9	1.1		3480
	30	22.4	208	1.15	88.0	27582	0.87	83.3	104.0	32597	0.87	81.8	445.0	H	0.1	0.1	6070	3420
			230		81.0	27105	0.84	85.1	92.0	31153	0.85	84.4	500.0					3470
			440		41.5	27199	0.86	84.5	48.0	31825	0.87	83.5	238.0	J	0.5	0.6		3450
			460		40.5	27105	0.84	85.1	46.0	31153	0.85	84.4	250.0					3470
			480		40.0	26937	0.81	85.2	45.0	31052	0.83	85.0	265.0					3480
			575		32.0	27089	0.85	84.8	37.0	31690	0.86	84.0	194.0	H	0.8	1.0		3460
	40	29.8	440	1.15	56.0	37130	0.87	84.7	65.0	43592	0.88	83.6	290.0	H	0.3	0.4	6070	3440
			460		54.5	36909	0.85	85.2	62.0	42482	0.86	84.7	310.0					3460
			480		54.5	37155	0.82	85.3	61.0	42600	0.84	85.1	330.0					3480
			575		43.5	36824	0.85	85.2	49.5	42890	0.87	84.7	250.0	G	0.6	0.7		3470

*Calculated Value (Voltage x Current x Cos F)

**Calculated Value (Full Load current x Locked Rotor Current %)

Table 19

Single Phase AC - $W = PF \times A \times V$

Three Phase AC - $P_{(W)} = \sqrt{3} \times PF \times I_{(A)} \times V_{L\text{-}L(V)}$

Square root of 3 = 1.7320508

6" Three Phase 60 Hz Motors

HP	kW	Voltage	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC)			NEMA Starter Size	IEC Starter Size
				Standard Fuse	Time Delay Fuse	Circuit Breaker		
7 1/2	5.6	208	27.5	80	45	60	1	E
		230	26.0	75	45	60	1	E
		440	13.2	40	20	30	1	C
		460	13.0	35	20	25	1	C
		480	13.0	35	20	25	1	C
		575	10.2	30	18	30	1	B
10	7.5	208	37.5	115	60	90	2	F
		230	33.5	100	60	80	2	F
		440	17.4	50	30	40	1	D
		460	16.8	50	30	40	1	D
		480	16.6	50	30	40	1	D
		575	13.4	40	20	30	1	C
15	11.2	208	53.5	160	90	125	2	H
		230	49.5	150	85	120	2	H
		440	25.0	75	40	60	2	E
		460	24.4	70	40	55	2	E
		480	24.0	70	40	55	2	E
		575	19.4	50	30	40	2	D
20	15.0	208	71.5	215	125	170	3	J
		230	65.0	195	110	155	3	J
		440	33.5	100	50	80	2	F
		460	32.5	90	50	70	2	F
		480	32.0	90	50	70	2	F
		575	26.0	75	45	60	2	E
25	18.6	208	87.0	260	150	200	3	K
		230	80.0	240	140	190	3	K
		440	41.0	120	72	90	2	G
		460	40.0	120	70	90	2	G
		480	39.5	120	70	90	2	G
		575	32.0	90	50	70	2	F
30	22.4	208	104.0	315	180	250	3	L
		230	92.0	275	160	220	3	L
		440	48.0	140	80	110	3	H
		460	46.0	135	80	100	3	H
		480	45.0	135	80	100	3	H
		575	37.0	110	65	85	3	G
40	29.8	440	65.0	190	110	150	3	J
		460	62.0	180	100	140	3	J
		480	61.0	180	100	140	3	J
		575	49.5	145	85	115	3	I

Table 20

Notes:
The Fuses and Circuit Breakers were calculated from the NEC table 430.52.
Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards.
The Overloads for submersible motorsshould be Class 10 Quick trip ambient compensated.

Fuses and Breaker Selection of Three-Phase Submersible Motors (Class 10 Protection Required)

Special overload protection is required for submersible motors. When a motor is locked, the overload protection must trip within 10 seconds to protect the windings from damage. Properly sized adjustable overload relay, fixed heater or a Grundfos MP204 motor protection device, should be installed to protect the motor and meet the Class 10 protection requirement. Fixed heater overloads must be ambient temperature compensated, quick trip design. Ambient temperature compensation allows for protection at high and low air temperatures. Values shown in the table below are based on total line amps. Always follow National, State and Local electrical codes for overload protection selection and setting.

6" 8" 10" Three Phase 60Hz Motors

Motor Type	Hp	kW	Volts	Service Factor	Full Load				Service Factor				Locked Rotor	KVA Code	Line-to-Line Resistance (Ω Ohms)		Thrust Bearing (LBS.)	RPM
					Amps	Watts*	Power Fact.	Eff. %	Amps	Watts*	Power Fact.	Eff. %	Amps**					
MMS 6	50	37.3	460	1.15	73.0	47111	0.81	83.2	82.0	54226	0.83	82.6	405	H	0.3	0.4	6000	3450
	60	44.7			86.3	57070	0.83	85.0	97.0	66464	0.86	86.0	525	G	0.4	0.5		3455
MMS 8000	40	29.8	460	1.15	53.3	36096	0.85	82.5	64.0	43853	0.86	83.0	371	K	0.3	0.4	13000	3490
	50	37.3			65.6	44426	0.85	83.7	78.0	53446	0.86	84.0	429	J	0.2	0.3		3480
	60	44.7			77.5	52485	0.85	85.4	92.5	64118	0.87	86.0	592	K	0.2	0.2		3500
	75	55.9			101.0	65182	0.81	85.8	112.0	77635	0.87	86.0	650	J	0.1	0.2		
	100	74.6			126.0	86335	0.86	86.6	150.0	105170	0.88	87.0	855		0.1	0.1		3500
	125	93.2			155.5	107787	0.87	86.9	184.0	129009	0.88	87.0	1104		0.1	0.1		3480
	150	111.9			186.2	129068	0.87	86.6	220.0	154250	0.88	86.0	1276		0.1	0.1		
MMS 10000	175	130.5	460	1.15	226.2	151388	0.84	86.5	265.0	181578	0.86	88.0	1511	J	0.0	0.1	13000	3510
	200	149.2			266.4	171924	0.81	86.6	305.0	204126	0.84	87.0	1891	K	0.0	0.1		3520
	250	186.5			339.8	213879	0.79	86.7	405.0	264598	0.82	87.0	2471		0.0	0.0		
MMS 8000	40	29.8	575	1.15	43.3	37086	0.86	81.0	49.0	42456	0.87	85.0	202	J	0.6	0.7	13000	3500
	50	37.3			55.5	46983	0.85	79.0	62.2	53274	0.86	84.0	257	G	0.4	0.5		
	60	44.7			62.0	53720	0.87	84.0	71.0	62226	0.88	85.0	465	J	0.4	0.4		
	75	55.9			79.1	67749	0.86	81.0	89.4	78352	0.88	85.0	586	L	0.3	0.4		3485
	100	74.6			104.0	91147	0.88	82.0	118.0	104592	0.89	86.0	786	N	0.2	0.3		3470
	125	93.2			118.4	104947	0.89	88.0	144.0	127638	0.89	86.0	1007	R	0.1	0.1		
	150	111.9			156.0	127399	0.82	86.0	176.0	147238	0.84	89.0	1230	H	0.1	0.1		

*Calculated Value (Voltage x Current x Cos F)

**Calculated Value (Full Load current x Locked Rotor Current %)

Table 21

MMS 6” Three Phase 60 Hz Motors

HP	kW	Voltage	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC)			NEMA Starter Size	IEC Starter Size
				Standard Fuse	Time Delay Fuse	Circuit Breaker		
50	37.3	460	82.0	240	140	190	3	N
60	44.7	460	97.0	290	170	230	4	–

Table 22

MMS 8” Three Phase 60 Hz Motors

HP	kW	Voltage	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC)			NEMA Starter Size	IEC Starter Size
				Standard Fuse	Time Delay Fuse	Circuit Breaker		
40	29.8	460	64.0	175	100	150	3	N
50	37.3		78.0	225	125	175		–
60	44.7		92.5	250	150	200	4	
75	55.9		112.0	300	175	250		
100	74.6		150.0	400	225	350		
125	93.2		184.0	500	300	400	5	
150	111.9		220.0	600	350	500		

Table 23

MMS 10” Three Phase 60 Hz Motors

HP	kW	Voltage	SF Amps	Fuses / Circuit Breakers (Maximum Per NEC)			NEMA Starter Size	IEC Starter Size
				Standard Fuse	Time Delay Fuse	Circuit Breaker		
175	130.5	460	265.0	700	400	600	5	-
200	149.2		305.0	800	500	700		
250	186.5		405.0	1100	600	1000	6	

Table 24

Notes:
The Fuses and Circuit Breakers were calculated from the NEC table 430.52.
Starters and Overloads should always be sized by a licensed electrician that is familiar with local codes and standards.
The Overloads for submersible motors should be Class 10 Quick trip Ambient compensated.

MOTOR

- Verify motor nameplate data meets the application – hp, voltage, phase, and Hertz.
- Check that the motor shaft rotates freely by hand on the second of two complete rotations. (On large motors, this usually requires a motor coupling with a cheater handle welded to it.)
- Check that the motor lead assembly is not damaged and is torqued properly.
- Measure cable insulation resistance to ground at 500 volts – BEFORE SUBMERGED. It should be a minimum of 200 megohms or 200,000,000 ohms.
- Measure cable insulation resistance to ground at 500 volts – AFTER SUBMERGED. It should be a minimum of 0.5 megohms or 500,000 ohms.
- Verify the system is operating within the ±10% of motor nameplate voltage requirement.
- Verify the system will not ever operate in excess of the maximum amps indicated on the nameplate.
- Verify the system is operating at 5% or less current unbalance.

Notice:

- Current unbalance between the phases should never exceed 5%. Under 3% should always be the goal. Contact your power company right away if the current unbalance between the phases exceeds 3%.
- The submersible motor amperage % unbalance is typically 6x greater than its voltage % unbalance.
- Thus, 0.8% voltage unbalance = greater than 5% current unbalance, and 1.7% voltage unbalance = greater than 10% current unbalance.

PUMP

- Verify the pump nameplate and curve data meets the application hp, rpm, and flow/TDH requirements.
- Verify the pump NPSH requirement will be met at all times. Make sure to check with the specific pump being used.
- Check that the pump shaft rotates freely by hand before installation.
- Check for proper up and down (shaft or shaft height) for the specific pump being used.
- Check that the cable guard is not pinching the motor leads, especially where it enters and exits the guard.

Notice:

- ***Pumps and motors 5 hp and above should be assembled in a vertical position to ensure correct alignment.***
- ***A motor-pump assembly 5 hp and above should never be lifted from a non-vertical position by the pump discharge because it can bend the shaft in one or both of the products.***

POWER SUPPLY (Three-Phase)

- Verify the transformer kVA rating is adequate for the motor per the Grundfos Motor Guide requirement.
- Verify that all transformers have the same kVA rating.
- Verify the Three-Phase pump fuses or its circuit breaker are correctly sized per the Grundfos Motor Guide requirement.
- Verify the Three-Phase pump motor contactor is correctly sized per the Grundfos Motor Guide requirement.
- Verify the Three-Phase pump motor overload is ambient compensated.
- Verify the Three-Phase pump motor overload is NEMA Class 10.
- Verify the Three-Phase pump motor overload heaters are correctly selected based on the system's operating point and the maximum motor operating amps.
- At no time should the system operating amps or the motor overload system running point setting be higher than the motor nameplate maximum amp rating.
- Verify that the Grundfos MP204 motor protector is set correctly if used. Either Class 10 or "P" setting.

Notice:

- ***Electronic overloads should be set at the motor nameplate amps.***

MS 402 4” Motor Dimensional Drawing

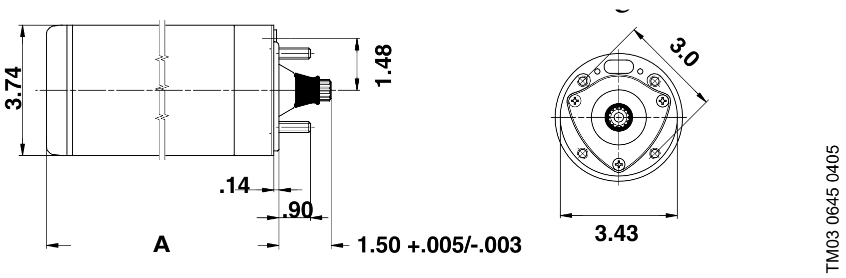


Fig. 6

MS 6000C 6” Motor Dimensional Drawing

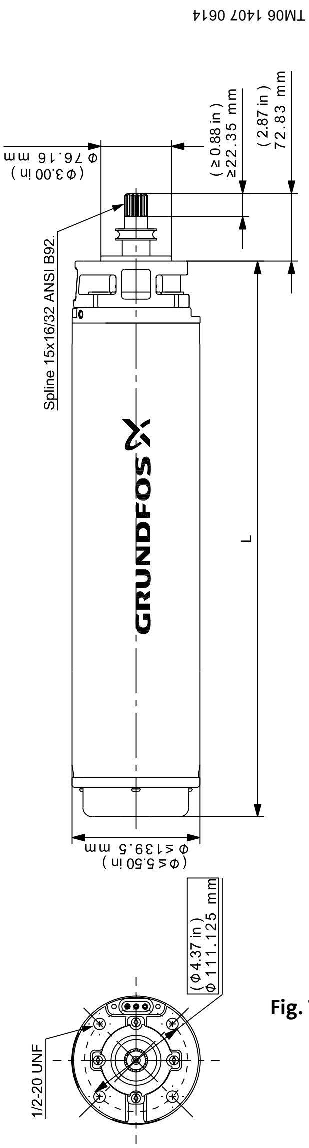


Fig. 7

MS 402 4” Motor Dimensions

Grundfos Motor Type	Standard Motor Output		Phase	Frequency	A-Dimensions	Motor Weight
	P2 HP	P2 kW	PH	Hz	in. (mm)	lbs. (kg)
MS 402	1/2	0.37	1	60	11.0 (279.4)	21.0 (9.5)
	3/4	0.55			11.6 (294.6)	22.3 (10.1)
	1	0.75			12.2 (309.9)	23.6 (10.7)
	1-1/2	1.10			13.7 (348.0)	28.0 (12.7)
MS 402	1/2	0.37	3	60	9.0 (228.6)	17.2 (7.8)
	3/4	0.55			9.6 (243.8)	18.7 (8.5)
	1	0.75			11.0 (279.4)	20.7 (9.4)
	1-1/2	1.10			12.2 (309.9)	23.6 (10.7)
	2	1.50			13.7 (348.0)	27.3 (12.4)

Table 25

MS 4000 4” Motor Dimensions

Grundfos Motor Type	Standard Motor Output		Phase	Frequency	A-Dimensions	Motor Weight
	P2 HP	P2 kW	PH	Hz	in. (mm)	lbs. (kg)
MS 4000	2	1.50	1	60	19.5 (495.3)	44.1 (20.0)
	3	2.20			22.6 (574.1)	53.0 (24.0)
	5	3.70			26.6 (675.6)	64.9 (29.0)
MS 4000	3	2.20	3	60	18.0 (457.2)	39.7 (18.0)
	5	3.70			22.7 (576.6)	52.9 (24.0)
	7-1/2	5.50			26.6 (675.6)	63.9 (29.0)
	10	7.50			30.6 (777.24)	72.8 (33.0)

Table 26

MS 6000C 6” Motor Dimensions

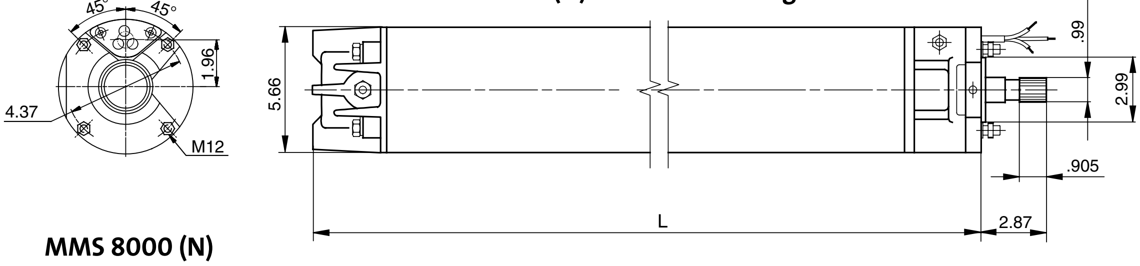
Grundfos Motor Type	Standard Motor Output		Phase	Frequency	L-Dimensions	Motor Weight
	P2 HP	P2 kW	PH	Hz	in. (mm)	lbs. (kg)
MS 6000C	5	3.70	3	60	26.4 (670.60)	81.6 (37.0)
	7-1/2	5.50			23.5 (597.0)	97.0 (44.0)
	10	7.50			24.7 (627.4)	103.6 (47.0)
	15	11.00			27.1 (688.3)	125.7 (57.0)
	20	15.00			29.6 (751.84)	143.3 (65.0)
	25	18.50			31.8 (807.72)	152.2 (69.0)
	30	22.00			34.1 (866.14)	169.8 (77.0)
	40	30.00			39.3 (998.2)	200.6 (91.0)

Table 27

MMS 6", 8", 10" Motor Dimensional Drawing

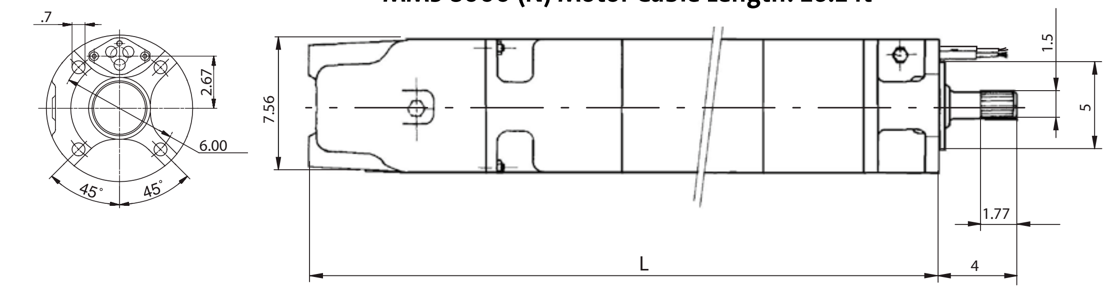
MMS 6 (N)

MMS 6000 (N) Motor Cable Length: 16.4 ft



MMS 8000 (N)

MMS 8000 (N) Motor Cable Length: 26.2 ft



MMS 10000 (N)

MMS 10000 (N) Motor Cable Length: 26.2 ft

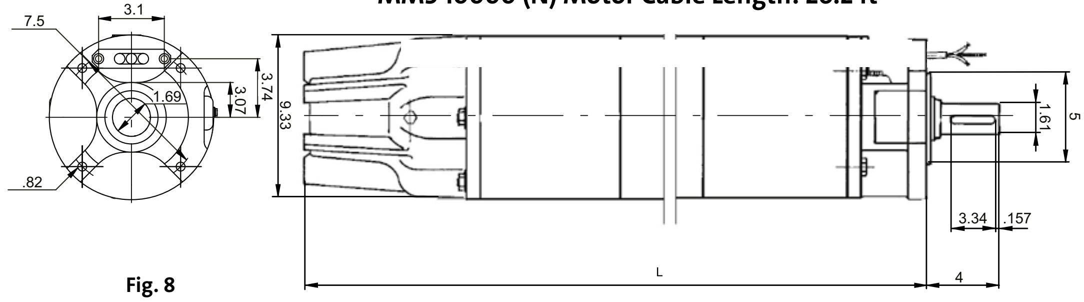


Fig. 8

MMS 6, 8000, 10000, 6" 8" 10" Motor Dimensions

Grundfos Motor Type	Standard Motor Output		Phase	Frequency	L-Dimension	Motor Weight
	P2 HP	P2 kW	PH	Hz	in. (mm)	lbs. (kg)
MMS 6	50	37.00	3	60	51.6 (1310.6)	302.4 (137.0)
	60	45.00			56.1 (1425.0)	308.7 (140.0)
MMS 8000	40	30.00	3	60	43.7 (1110.0)	361.6 (164.0)
	50	37.00			45.6 (1158.2)	383.6 (383.6)
	60	45.00			50.0 (1270.0)	4.29.9 (195.0)
	75	55.00			53.1 (1348.7)	467.4 (212.0)
	100	75.00			62.5 (1587.5)	566.6 (257.0)
	125	92.00			72.0 (1828.8)	674.6 (306.0)
	150	110.00			81.1 (2060.0)	784.9 (356.0)
MMS 10000	175	132.00	3	60	73.6 (1869.4)	1040.6 (472.0)
	200	147.00			81.5 (2070.1)	1102.3 (500.0)
	250	190.00			94.5 (2400.3)	1360.3 (617.0)

Table 28

POWER SUPPLY (1-PHASE)
- Verify the transformer kVA rating is adequate for the motor per the Grundfos Motor Guide requirement.
- Verify the motor control box hp rating and its voltage match the motor rating. If not, a premature failure of the control box or motor should be expected.

ELECTRICAL SURGE PROTECTION
- Verify the submersible motor has a dedicated surge arrestor. All submersible motors require a dedicated surge arrestor. Motors 5 hp and smaller marked "Equipped with Lightning Arrestors", have a built-in surge arrestor.
- Verify that the surge arrestor is mounted as close to the motor as practical. The location is usually in the pump panel, but sometimes it is placed at the well head in a separate electrical box.
- Verify the surge arrestor is grounded below the lowest drawdown water level. This is usually accomplished by attaching the drop cable ground wire to the motor lead or the motor ground.
- Verify the ground conductor size meets the minimum requirements of the National Electric Code and all other relevant.
- Verify the motor ground is connected to the electrical system ground.

ELECTRICAL DROP CABLE
- Verify the temperature rating of the drop cable – typically 60 °C, 75 °C, 90 °C or 125 °C (140 °F, 167 °F, 194 °F or 257 °F).
- Verify whether the cable is single conductor or jacketed conductor.
- Verify the conductor size – typically AWG, MCM or mm^2.
- Verify if the conductor material is copper; if not, determine the material and contact the factory for acceptability.
- Verify the drop cable meets or exceeds the requirements of NEC, State and Local electric codes and the Grundfos Motor Guide.

Notice:
- ***If the service entrance to pump panel or from the pump panel to motor cable is not a copper material, contact the factory for the correct length derating factors.***

MOTOR COOLING
- Verify that the well water temperature does not exceed the maximum ambient temperature indicated on the nameplate of the motor.
- Verify there is a minimum of 10 feet of clear water between the bottom of the motor and the bottom of the well.
- Verify that all water entering the well is coming from below the lowest part of the motor.
- When using a VFD verify that at the lowest speed you can still meet the minimum flow past motor
- **Verify that Three-Phase motors above 7.5 hp in a vertical potable water well should not exceed 100 starts in 24 hours and each start should include a minimum of 3 minutes ON and 10 minutes OFF.**

Notice:
- ***If any water is entering the well above the lowest part of the motor, a flow sleeve is required.***

MOTOR-PUMP INSTALLATION
- Verify that the drop cable is supported to the drop pipe every 10 feet.
- Verify at least one spring loaded (non-drilled) check valve is in the drop pipe. Preferably, the first check valve should be located at the top of the first pipe joint above the pump discharge (~20 feet) if the pump does not have a check built in to its discharge.
- Verify all pipe joints are as tight as practical. Do not overtighten.
- Verify the rotation of the pump is correct. It is preferable to do this by checking the flow and current in both directions on Three-Phase motors. This can be done by having the electrician swap any two leads. This is considered "best practice" since pumps under some conditions can supply amp readings and a visual flow observation that can be extremely misleading.

Should be filled out at time of install (Page 1 of 2)

DISTRIBUTOR INFORMATION

Distributor Name ____________

Distributor Contact ____________

Phone (   ) ____________

Fax (   ) ____________

INSTALLER INFORMATION

Installer's Name ____________

Address ____________

City ____________ State ____ Zip ____________

Phone (   ) ____________ Fax (   ) ____________

Contact Name ____________

OWNER INFORMATION

Owner's Name ____________

Address ____________

City ____________ State ____ Zip ____________

Phone (   ) ____________ Fax (   ) ____________

Contact Name ____________

Well Name/ID ____________

Date Installed ____________ Date Failed ____________

Water Temperature ____________ °F ____________ °C

MOTOR:

Motor Manufacturer ____________

Motor Product No. ____________

Motor Model ____________

Serial No./Date Code ____________ HP ______ Voltage ______ PH ______

⇨ 1 PH: ◯ 2-wire or ◯ 3-wire *(check one)*

Full Load Current ____________ SF Amps ____________

PUMP:

HP Required by Pump End ____________

Manufacturer ____________ Model No. ____________

Curve No. ________ Rating: ________ GPM@ ________ ft. TDH

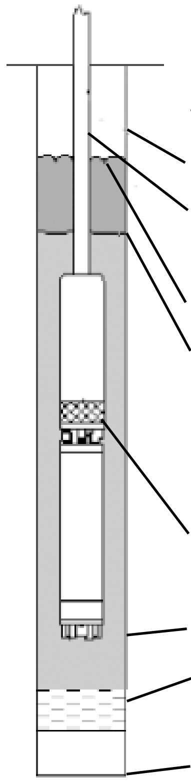
NPSH Required ____________ ft. NPSH Available ____________ ft.

Actual Pump Delivery ____________ GPM@ ____________ PSI

Operating Cycle:

ON (Hr./Min.) ____________ OFF (Hr./Min.) ______

Your Name ____________ **Date** ___ / ___ / ____



WELL DATA:

Total Dynamic Head ____________ ft.

Casing Diameter ____________ in.

Drop Pipe Diameter ____________ in.

Drop Pipe Length ____________ in.

Static Water Level ____________ ft.

Drawdown (pumping) Water Level ______ ft.

Check Valves at ________ & ________ &

________ & ________ ft.

◯ Solid ◯ Drilled

Pump Inlet Setting ____________ ft.

Flow Sleeve ◯ No ◯ Yes, Dia. ________

Casing Depth ____________

◯ Well Screen ◯ Perforated Casing

From ______ to ______ ft. & ______ to ______ t.

Well Depth ____________ ft.

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

Should be filled out at time of install (Page 2 of 2)

POWER SUPPLY:

Cable: Service Entrance to pump panel _____ ft._____ AWG/M

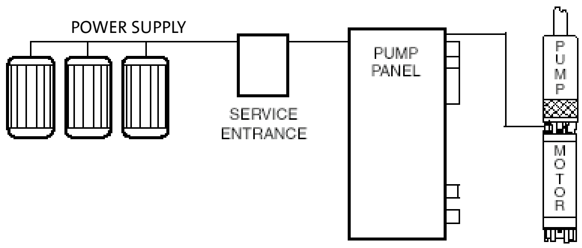
◯ Copper ◯ Aluminum

◯ Jacketed ◯ Individual Conductors

Cable: Pump panel to Motor _____ft. ______AWG/MCM

◯ Copper ◯ Aluminum

◯ Jacketed ◯ Individual Conductors



POWER SUPPLY:

Wye or Delta *(check one)*

If Delta, is it an open or closed configuration?

◯ Open = 2 transformers ◯ Closed = 3 transformers

Output Voltage ______________________________

KVA available ______________________________

INCOMING VOLTAGE TO PUMP PANEL:

No Load L1-L2 _________ L2-L3 _________ L1-L3 _________

Full Load L1-L2 _________ L2-L3_________ L1-L3 _________

L1-G _________ L2-G _________ L3-G _________

INSULATION CHECK:

Initial Megs: Motor & Lead Only: Black_____Yellow_____Red_____

Installed Megs: Motor, Lead & Cable: Black_____Yellow_____Red _____

RUNNING AMPS: *(For single phase applications L2 is = Neutral)*

HOOKUP 1:

Full Load L1_________L2 _________L3 _________

% Unbalance ____________

HOOKUP 2:

Full Load L1_________L2 _________L3 _________

% Unbalance ____________

HOOKUP 3:

Full Load L1_________L2 _________L3 _________

% Unbalance ____________

Ground Wire Size _________________________AWG/MCM

System Grounded to:

◯ Well Head ◯ Motor ◯ Rod ◯ ower Supply

Motor Surge/Lightning Protection ◯ Yes ◯ No Mfg.___________

DC Ground Current ____________ mA

PUMP PANEL:

Pump Panel Manufacturer ______________________________

Short Circuit Device

◯ Circuit Breaker

◯ Fuses

◯ Non-Time Delay Amp Rating ________________

◯ Time Delay Amp Rating ________________

Lightning/Surge Protection: ◯ Yes ◯ No

Lightning/Surge Protection: Mfg. __________ Model __________

Type of Starter ◯ Full Voltage ◯ Soft Start ◯ VFD

Mfr.___________Model____________ TDH ______________

Setting____% Full Volt. In____Sec. (Accel.)___

VFD Accel. Time 0 to 30 Hz.:_____Sec. Max. Freq._____ Hz.

VFD Decel. Time 30 to 0 Hz.:_____Sec. Min. Freq._____Hz.

Volts/Hz. Profile (Linear or non-Linear) ______________

If Non-Linear, how configured? ______________

Output filter mfg. _______________ Type_____________

OVERLOAD PROTECTION:

Overload Relay Manufacturer ______________________

Part # _______________Model ______________________

Heater _______________Part # _____________________

Class ________________Range ______________________

If Adjustable, Set at _______amps.

CUE ◯ or MP204 ◯

Warranty Registration No. ______________________

Current Stop Limits: Max_____A, Min_____A

(To view the next section of warning and stop limits, an R100 is required):

	War.		Stop	
Temp. Limits	___C°		___C°	
Current War. Limits	___A		___A	
Voltage Limits	Low	High	Low	High
	____	____	____	____
Unbalance Limits	____%		____%	

Other electronic adjustable device:

MFG: __________ Model: ______________________

Overload Set: ______________________________

Underload Set: ______________________________

Single phase control box:

MFG: __________ Model: ______________________

Start Capacitor:____-____mf. Measured value:____

Run Capacitor: ____-____mf. Measured value:____

Motor Protection MP204

MP204 protection and monitoring parameters

- Date and time stamp on faults
- Insulation resistance before start-up
- Temperature (Tempcon, PT sensor and thermal switch)
- Overload / underload
- Overvoltage / undervoltage
- Phase sequence
- Phase missing
- Power factor (cos ϕ)
- Power consumption
- Harmonic distortion
- Current unbalance
- Run and start capacitor (single-phase)
- Operating hours and number of start

Dimensions

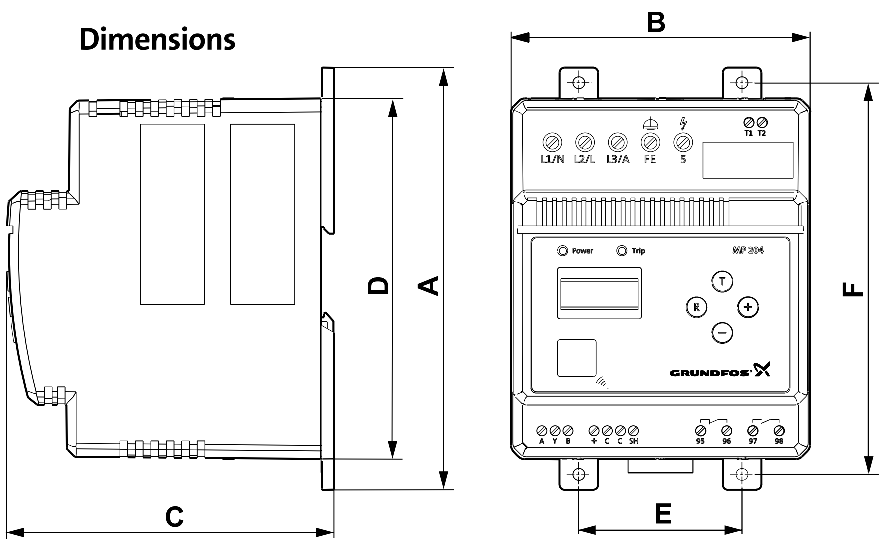


Fig. 6

A	B	C	D	E	F
[in. (mm)]					
6.46 (164)	4.57 (116)	5.00 (127)	5.52 (140)	2.49 (63)	5.95 (151)

All dimensions are [in. (mm)].

Motor Protection MP204

Startup and Operation:

A basic setting of the MP 204 can be made on the control panel. Additional functions must be set with the R100 remote control, Grundfos GO or PC Tool Water Utility.

Control panel

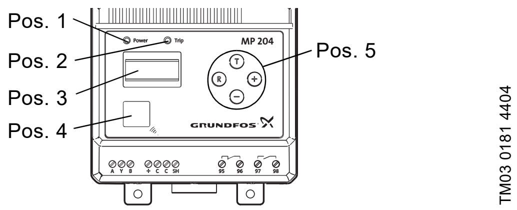


Fig. 9

Pos.	Description	Explanation
1	"Power" indicator light	• Flashes green until the MP 204 is ready for operation (power-on delay). • Is permanently green when the MP 204 is ready for operation. • Flashes red when communicating with the R100 or Grundfos GO.
2	"Trip" indicator light	Is red when the trip relay is activated.
3	Display	4 digits, for basic setting and data reading.
4	IR field	R100 or Grundfos GO communication.
5	Operating buttons	[T] [R] [+] [-] Setting and operation.

Button (Test)

Press [T] button to open trip relay connection 95-96 and close signal relay connection 97-98. The red "Trip" indicator light is on. The function is identical to the overload trip.

Button (Reset)

Press [R] button to change the tripped state to normal state with trip relay connection 95-96 closed and signal relay connection 97-98 open. The red "Trip" indicator light is off. This implies that the tripped state has actually ceased. The [R] button also resets warnings, if any.

Button (+)

Normally the actual current or temperature appears in the display. Press [+] button to show information in the display, according to the following sequence:

Sequence in display

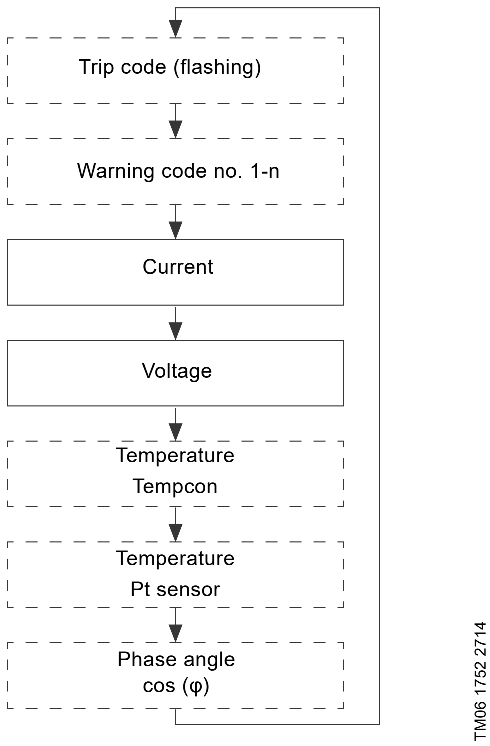


Fig. 10

- The trip code only appears if the MP 204 is tripped. Switches between "trip" and trip code.
- The warning code only appears if the limit value of one or more warnings has been exceeded, and if warning code indication has been activated.
- Temperatures only appear if the matching sensors have been connected and activated. If no Tempcon signal is received, "----" appears in the MP 204 display.
- Cos (φ) only appears if this indication has been activated with the R100 or Grundfos GO.

When the motor is operating, the display shows the actual value.

When the motor stops, the display shows the last measured value.

Button (-)

Only used in connection with the basic setting of the MP 204.

Motor Protection MP204

Setting on control panel

Press [+] and [-] buttons simultaneously for a minimum of 5 seconds to place the MP 204 in the programming mode. When the display shows "....", the buttons can be released.

The set value, e.g. "4.9 A", appears. The unit symbol "A" is flashing.

Enter the values of

- rated current
- nominal voltage
- trip class
- number of phases.

Note ***Insulation measurement is only possible of grounded (earthed) three-phase systems.***

If no buttons are activated, the voltage appears after 10 seconds.

After a further 10 seconds, the set voltage is stored automatically, and the programming mode ends. See Fig.11.

Note ***Changes in rated current must be finished by pressing [T] to store the change.***

Rated current

Set the rated motor current with [+] and [-] buttons. (See motor nameplate.)

- Press [T] to store the setting and continue, or
- Press [R] to cancel the change and finish.

The programming mode ends automatically after 10 seconds, and the change is canceled. See Fig. 11.

Nominal voltage

Set the nominal voltage with [+] and [-] buttons.

- Press [T] to store the setting and continue, or
- Press [R] to store the setting and finish.

The programming mode ends automatically after 10 seconds, and the change is stored. See Fig. 11

Trip class

Set the trip class with [+] and [-] buttons.

For submersible pumps, manual setting of the trip delay, class "P", is normally selected. The time is factory-set to 10 seconds. It can be changed with the R100 or Grundfos GO.

For other pumps, the required IEC trip class (1-45) is to be set. Normally class 10 is selected.

- Press [T] to store the setting and continue, or
- Press [R] to store the setting and finish.

The programming mode ends automatically after 10 seconds, and the change is stored. See Fig. 11.

Number of phases

Set the number of phases with [+] and [-] buttons (1 phase, 3 phases (non-grounded (non-earthed)) or 3 phases w. FE (functional ground (earth)).

- Press [T] to store the setting and continue, or
- Press [R] to store the setting and finish.

The programming mode ends automatically after 10 seconds, and the change is stored. See Fig. 11.

Example of basic settings display

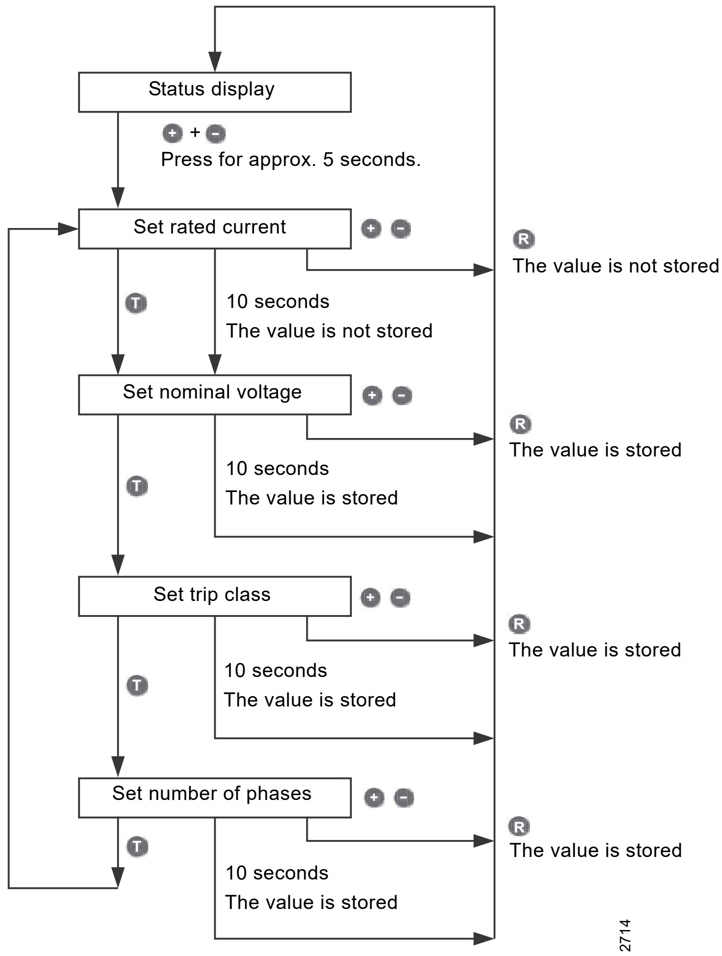


Fig. 11

TM06 17153 2714

Learning function

The learning function is factory-set to "Enable".

After two minutes of continuous motor operation, "LRN" appears in the display for approx. 5 seconds, while the values are being stored in the MP 204.

If, for instance, a Pt sensor or capacitor has been replaced, reactivate the learning function by pressing [R] and [-] buttons for a minimum of 10 seconds.

The dot in the right side of the display is flashing. The MP 204 is waiting for current to pass through the unit for a minimum of 120 seconds. Then the phase sequence is measured and stored.

In single-phase systems, the MP 204 measures the capacity of the starting and run capacitors and stores the values as reference.

If a Pt100/Pt1000 sensor is installed, the cable impedances to the sensor are measured and stored as reference.

Motor Protection MP204 Fault / Warning Codes

Fault Code	Trip	Warning	Cause of trip/warning
2	A	-	Missing phase
3	A	-	PTC/thermal switch
4	A	-	Too many automatic restarts per 24 hours
9	A	-	Wrong phase sequence
12	-	E	Service warning
15	A	-	Communication alarm for main system
18	A	-	Commanded trip (not in alarm log)
20	A	E	Low insulation resistance
21	-	E	Too many starts per hour
26	-	E	the motor is operating even if the MP 204 is tripped
32	A	E	Overvoltage
40	A	E	Undervoltage
48	A	E	Overload
56	A	E	Underload
64	A	E	Overtemperature, Tempcon measurement
71	A	E	Overtemperature, Pt100/Pt1000 measurement
91	-	E	Signal fault, Tempcon sensor
111	A	E	Current unbalance
112	A	E	Cos (ϕ), max.
113	A	E	Cos (ϕ), min.
120	A	-	Auxiliary winding fault
123	A	E	Starting capacitor, low
124	A	E	Run capacitor, low
175	-	E	Signal fault, Pt100/Pt1000 sensor

Table 29

MP204 Setting Ranges

Setting Ranges	Setting Range	Resolution
Current without external current transformer	3-120 A	0.1 A
Current with external current transformer	120-999 A	1 A
Phase-to-phase voltage	80-610 VAC	1 V
Temperature via Pt100/Pt1000	32-356 °F (0-180 °C)	1.8 °F (1 °C)
Temperature via Tempcon	32-257 °F (0-125 °C)	1.8 °F (1 °C)
Power factor (cos (ϕ))	0 - 0.99	0.01
IEC trip class	1-45 and "P"	1
Special trip class "P" (pump), trip delay	0.1 - 30 s	0.1 s
External current transformer factor	1-100	1
Run capacitor (single-phase)	10-1000 µF	1 µF
Starting capacitor (single-phase)	10-1000 µF	1 µF
Number of starts per hour	0-65535	1
Number of starts per 24 hours	0-65535	1
Trip delay (other than current)	1-100 s	1 s
Automatic restarting time	10-3000 s	10 s
Power-on delay	1-19 s	1 s

Table 31

MP204 Measuring Ranges

Measuring Ranges	Measuring Range	Accuracy	Resolution
Current without external current transformer 3-120 A ± 1 % 0.1 A	3-120A	± 1 %	0.1 A
Current with external current transformer 120-999 A ± 1 % 1 A	120-999A	± 1 %	1 A
Phase-to-phase voltage 80-610 VAC ± 1 % 1 V	80-610 VAC	± 1 %	1 V
Frequency 47-63 Hz ± 1 % 0.5 Hz	47-63 Hz	± 1 %	0.5 Hz
Insulation resistance 10-1 MΩ ± 10 % 10 kΩ	10-1 MΩ	± 10 %	10 Kω
Temperature via Pt100/Pt1000 32-356 °F (0-180 °C) ± 1.8 °F (± 1 °C) 1.8 °F (1 °C)	32-356 °F (0-180 °C)	± 1.8 °F (± 1 °C)	1.8 °F (1 °C)
Temperature via Tempcon 32-257 °F (0-125 °C) ± 5.4 °F (± 3 °C) 1.8 °F (1 °C)	32-257 °F (0-125 °C)	± 5.4 °F (± 3 °C)	1.8 °F (1 °C)
Power consumption 0-16 MW ± 2 % 1 W	0-16 MW	± 2 %	1 W
Power factor (cos (ϕ)) 0 - 0.99 ± 2 % 0.01	0 - 0.99	± 2 %	0.01
Run capacitor (single-phase) 10-1000 µF ± 10 % 1 µF	10-1000 Mf	± 10 %	1 µF
Starting capacitor (single-phase) 10-1000 µF ± 10 % 1 µF	10-1000 µF	± 10 %	1 µF
Number of starts 0-65535 - 1	0-65535	-	1
Energy consumption 0-4 x 109 kWh ± 5 % 1 kWh	0-4 x 109 kWh	± 5 %	1 kWh

Table 30

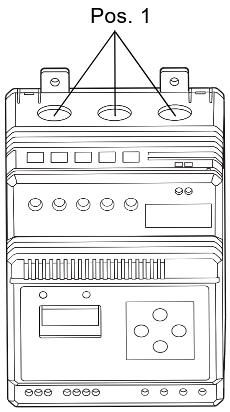


Fig. 12

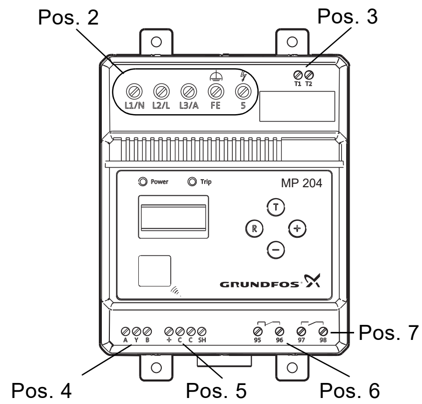


Fig. 13

Measuring Ranges

Position	Designation	Three-Phase Connection	Single Phase Connection	Cable
1	I1	Entry for phase L1 to motor	Entry for neutral	Max. Ø16 mm 2 AWG
	I2	Entry for phase L2 to motor	Entry for phase	
	I3	Entry for phase L3 to motor	Entry for auxiliary winding	
2	L1/N	Supply: L1	Supply: Neutral	Max. 6[1)] mm² 10 AWG
	L2/L	Supply: L2	Supply: Phase	
	L3/A	Supply: L3	Auxiliary winding	
	FE	Functional ground (Earth)		
	5	Insulation measurement		
3	T1	PTC/Thermal switch		Max. 2.5[2)] mm² 14 AWG
	T2			
4	A	GENIbus data A		
	Y	Reference/screen		
	B	GENIbus data B		
5	+	Pt100/Pt1000 sensor		
	C			
	C			
	SH	Screen		
6	95	Trip relay NC		
7	97	Signal replay NO		
	98			

Table 32

UL requirement:
For field wiring terminals, min. 140/167 °F (60/75 °C) stranded copper conductors must be used.

Wiring Diagram

MP204 - Three Phase with ACL/DOL Starter without Current Transformers

+ = Resistance input

C = Correction for lead resistance.
To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two “C” terminals are to be short-circuited.

At motor currents up to and including 120A, the cables to the motor can be taken direct through the I1–I2–I3 tubes of the MP204.

At motor currents above 120A, current transformers must be used.

If current transformers are used, then you must loop 5 windings of the current transformer leads through I1-I2-I3 of the MP204 per phase.

If the motor circuit breaker/fuses are greater than 50A, then you must fuse the inputs of the L1, L2, L3, and 5 terminals separately with max 10A fuses

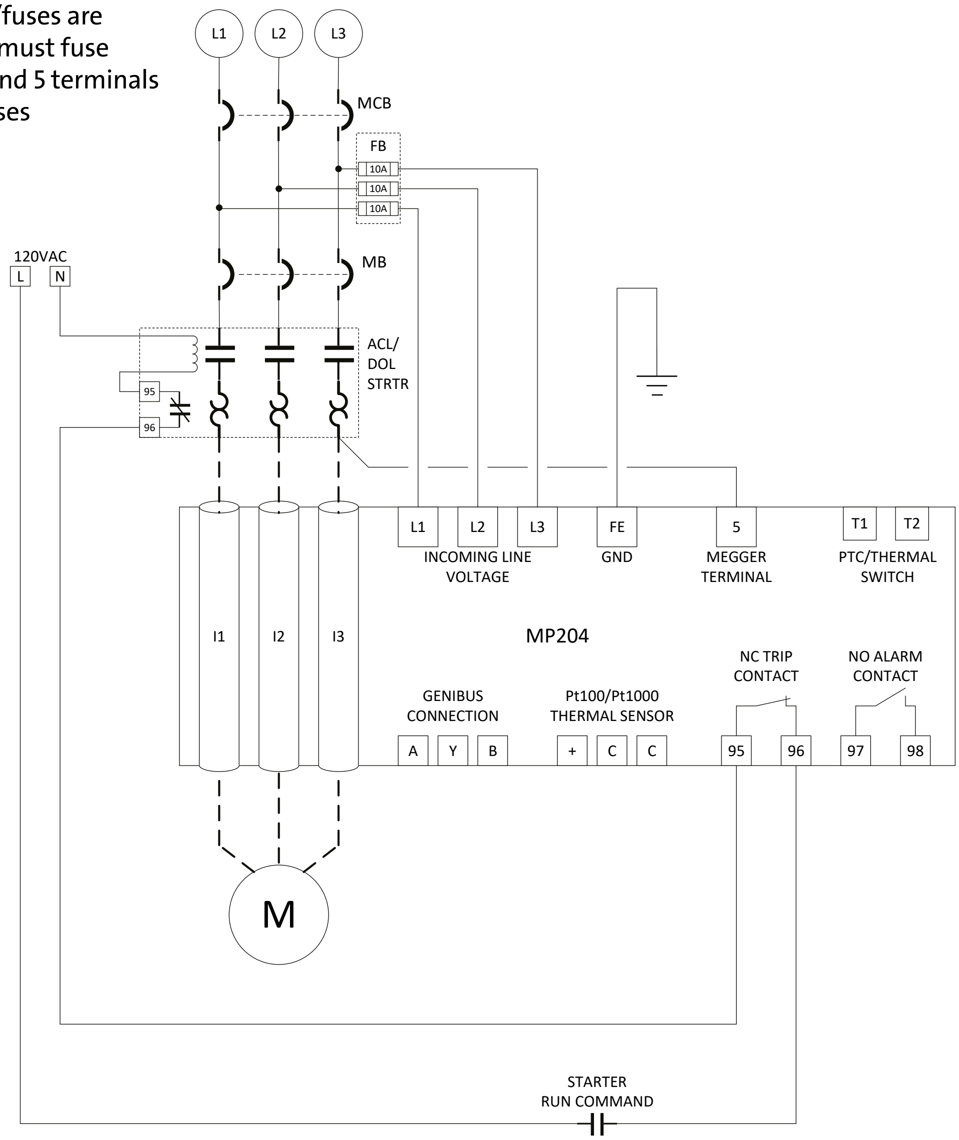


Fig. 14

Wiring Diagram

MP204 - Three Phase with ACL/DOL Starter with Current Transformers

+ = Resistance input

C = Correction for lead resistance.
To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two "C" terminals are to be short-circuited.

At motor currents up to and including 120A, the cables to the motor can be taken direct through the I1–I2–I3 tubes of the MP204.

At motor currents above 120A, current transformers must be used.

If current transformers are used, then you must loop 5 windings of the current transformer leads through I1-I2-I3 of the MP204 per phase.

If the motor circuit breaker /fuses are greater than 50A, then you must fuse the inputs of the L1, L2, L3, and 5 terminals separately with max 10A fuses.

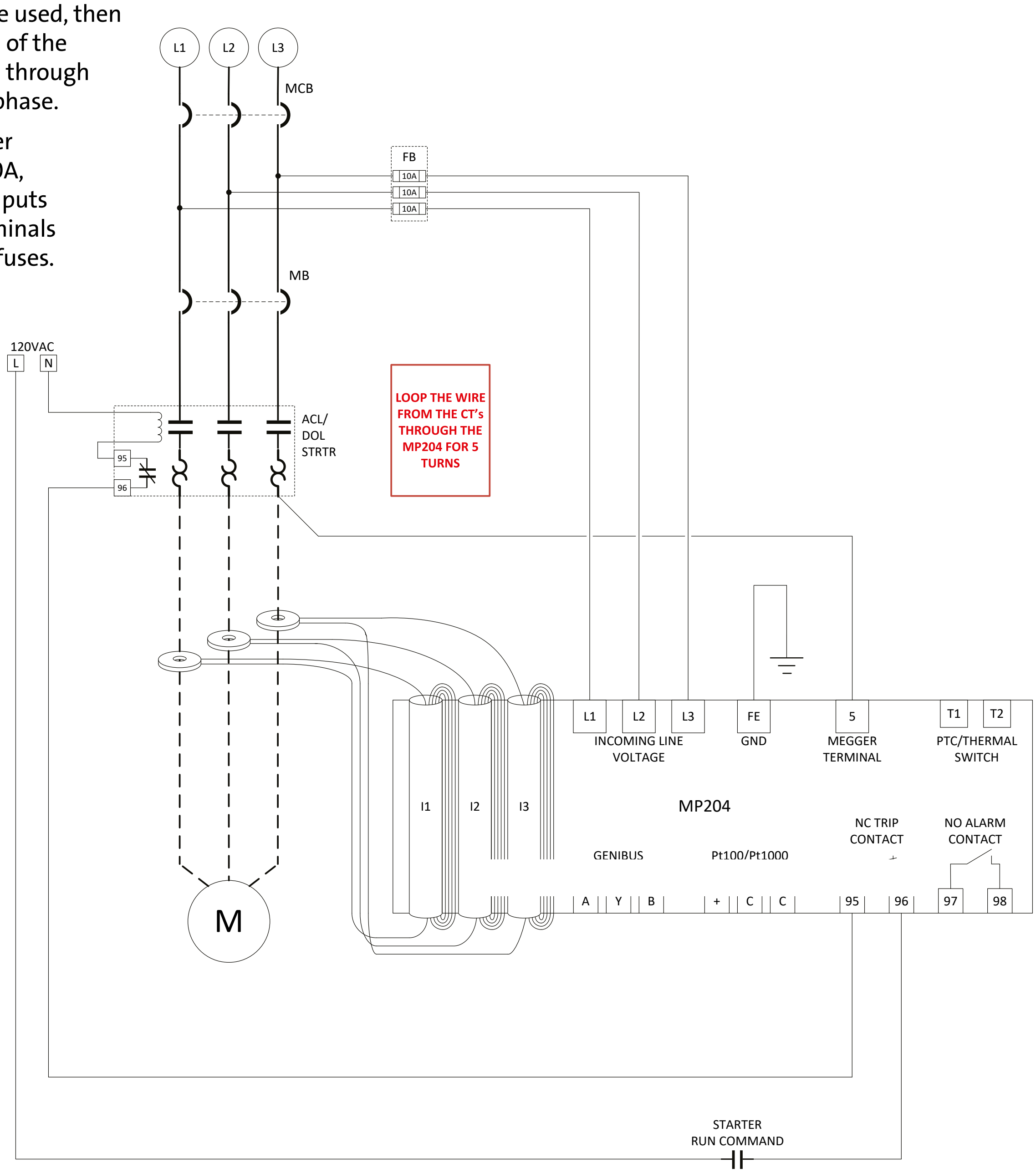


Fig. 15

Wiring Diagram

MP204 - Three Phase with Soft Start with Isolation, No Current Transformers

+ = Resistance input

C = Correction for lead resistance.
To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two “C” terminals are to be short-circuited.

At motor currents up to and including 120A, the cables to the motor can be taken direct through the I1–I2–I3 tubes of the MP204.

At motor currents above 120A, current transformers must be used.

If current transformers are used, then you must loop 5 windings of the current transformer leads through I1-I2-I3 of the MP204 per phase.

If the motor circuit breaker/fuses are greater than 50A, then you must fuse the inputs of the L1, L2, L3, and 5 terminals separately with max 10A fuses

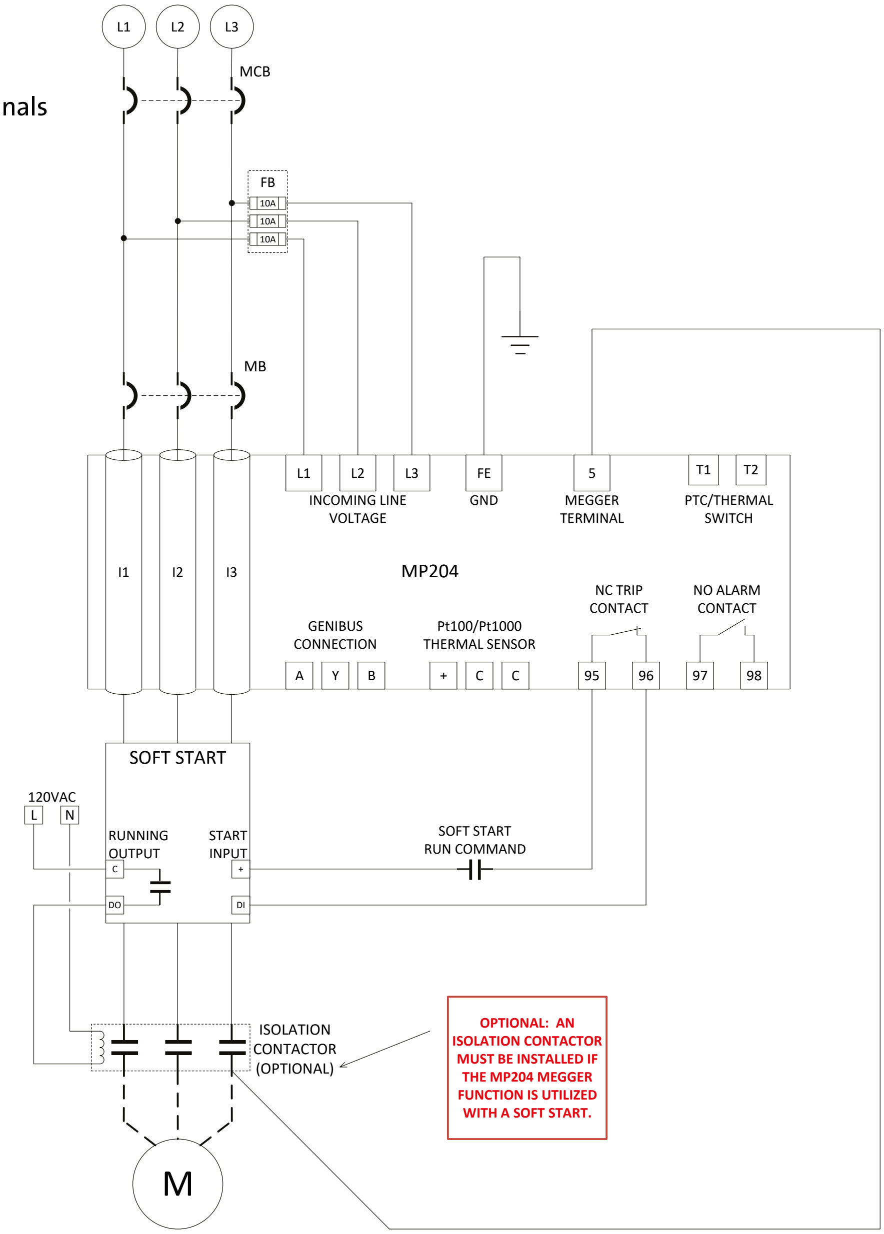


Fig. 16

Wiring Diagram

MP204 - Three Phase with Soft Start with Isolation, with Current Transformers

+ = Resistance input

C = Correction for lead resistance.
To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two "C" terminals are to be short-circuited.

At motor currents up to and including 120A, the cables to the motor can be taken direct through the I1–I2–I3 tubes of the MP204.

At motor currents above 120A, current transformers must be used.

If current transformers are used, then you must loop 5 windings of the current transformer leads through I1-I2-I3 of the MP204 per phase.

If the motor circuit breaker /fuses are greater than 50A, then you must fuse the inputs of the L1, L2, L3, and 5 terminals separately with max 10A fuses.

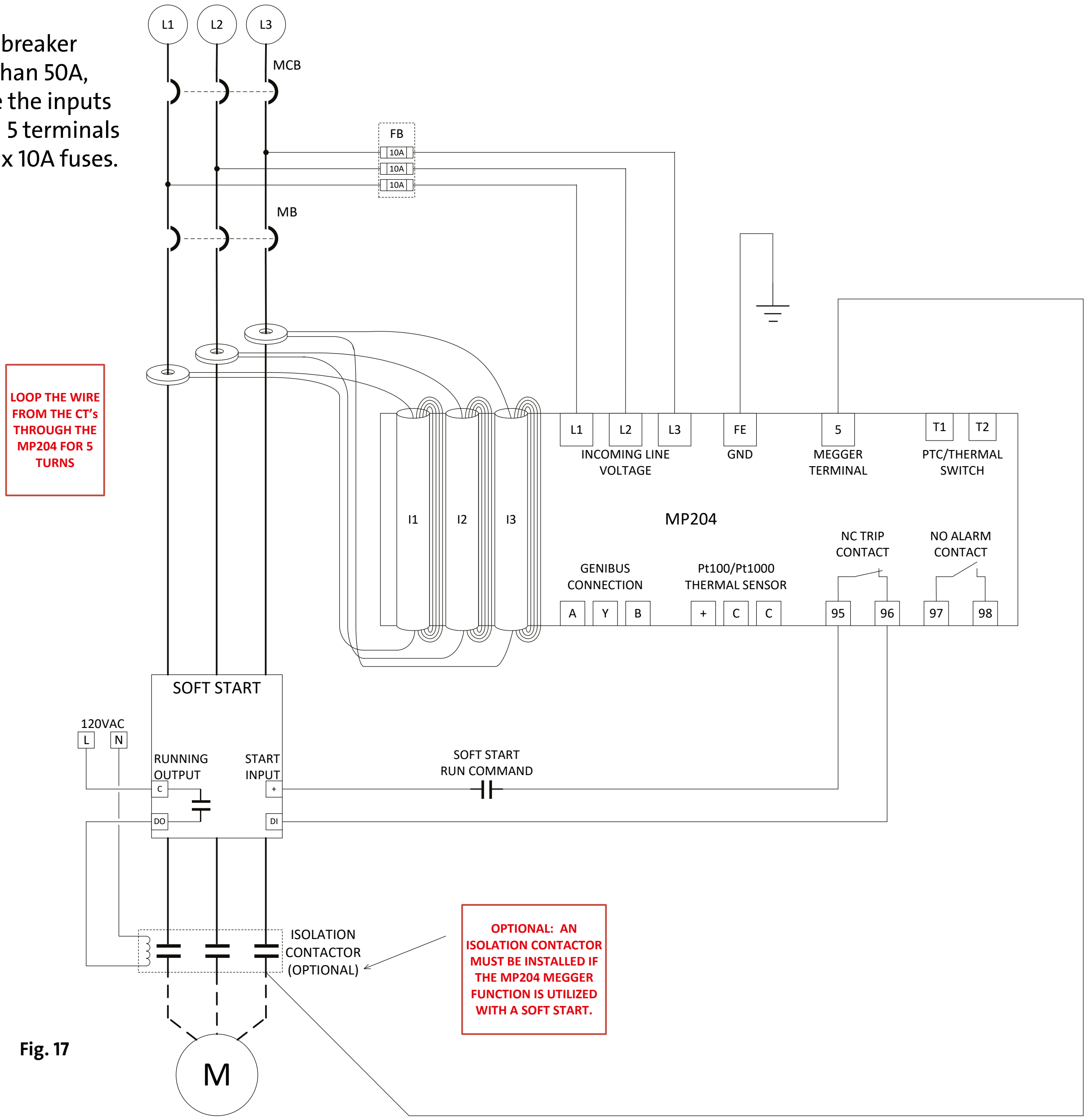


Fig. 17

Wiring Diagram
MP204 - Three Phase with VFD, with Isolation, No Current Transformers

+ = Resistance input

C = Correction for lead resistance.
To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two "C" terminals are to be short-circuited.

At motor currents up to and including 120A, the cables to the motor can be taken direct through the I1–I2–I3 tubes of the MP204.

At motor currents above 120A, current transformers must be used.

If current transformers are used, then you must loop 5 windings of the current transformer leads through I1-I2-I3 of the MP204 per phase.

If the motor circuit breaker/fuses are greater than 50A, then you must fuse the inputs of the L1, L2, L3, and 5 terminals separately with max 10A fuses.

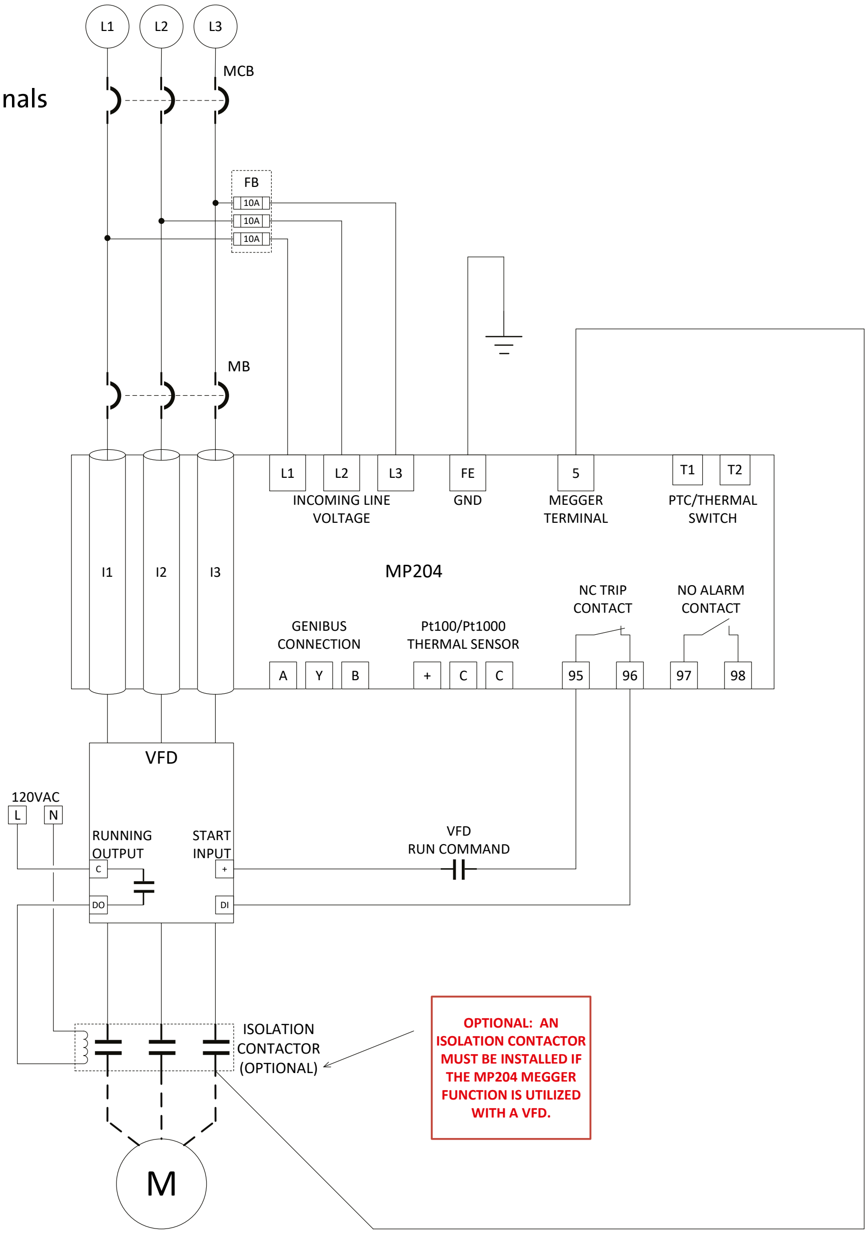


Fig. 18

Wiring Diagram

MP204 - Three Phase with VFD, with Isolation, with Current Transformers

+ = Resistance input

C = Correction for lead resistance.
To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two "C" terminals are to be short-circuited.

At motor currents up to and including 120A, the cables to the motor can be taken direct through the I1–I2–I3 tubes of the MP204.

At motor currents above 120A, current transformers must be used.

If current transformers are used, then you must loop 5 windings of the current transformer leads through I1-I2-I3 of the MP204 per phase.

If the motor circuit breaker /fuses are greater than 50A, then you must fuse the inputs of the L1, L2, L3, and 5 terminals separately with max 10A fuses.

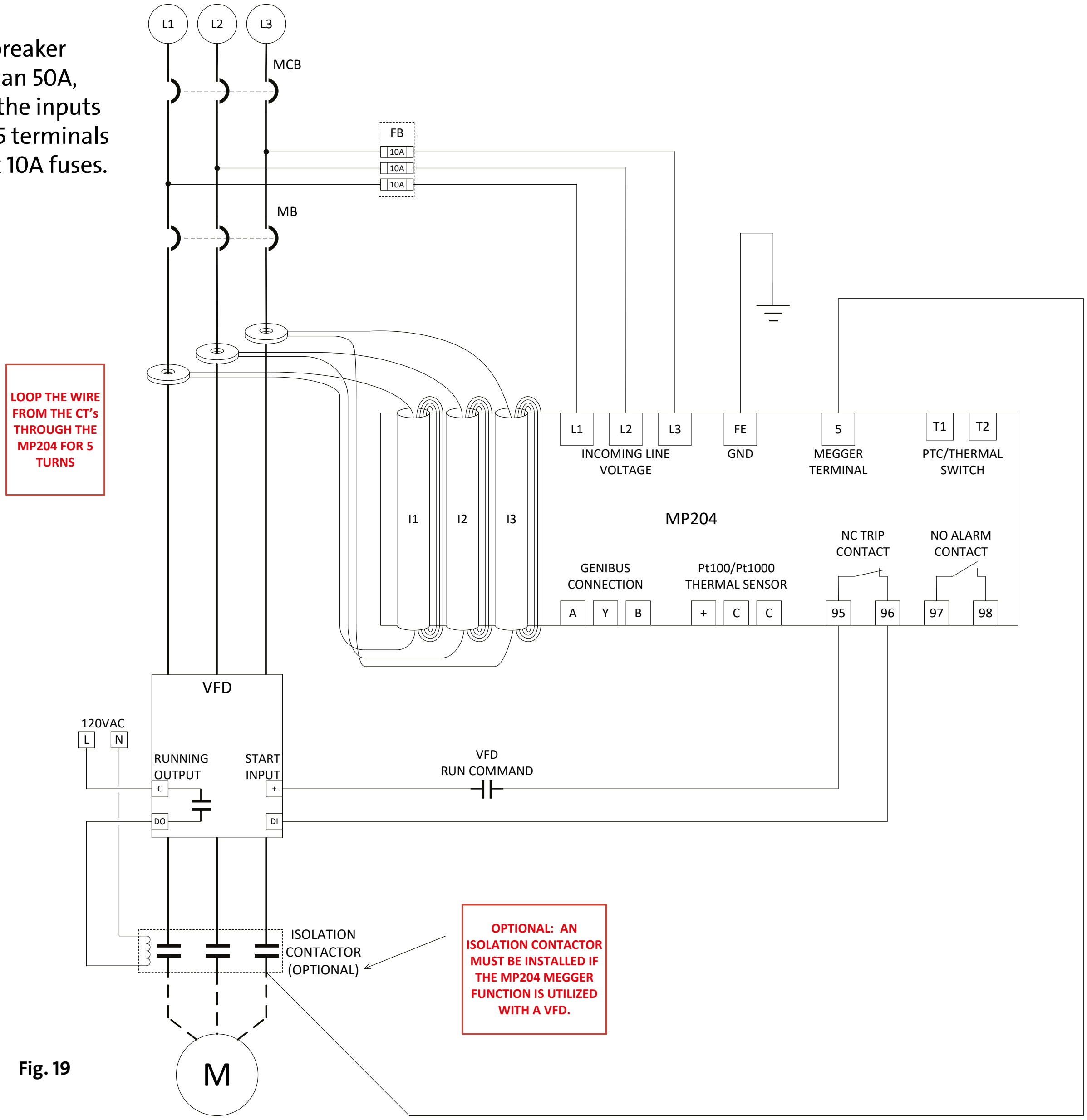


Fig. 19

External Current Transformers

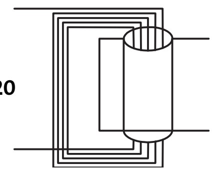
At motor currents above 120 A, external current transformers must be used. Fit the transformers as shown in Fig.20

Note *Take the three measuring cables through the three holes in the MP 204 five times per phase. See Fig. 20.*

Note *The three current transformers must be fitted in the same direction, and the measuring cables must be connected in the same way.*

Current transformers

Fig. 20



TM03 1398 1905

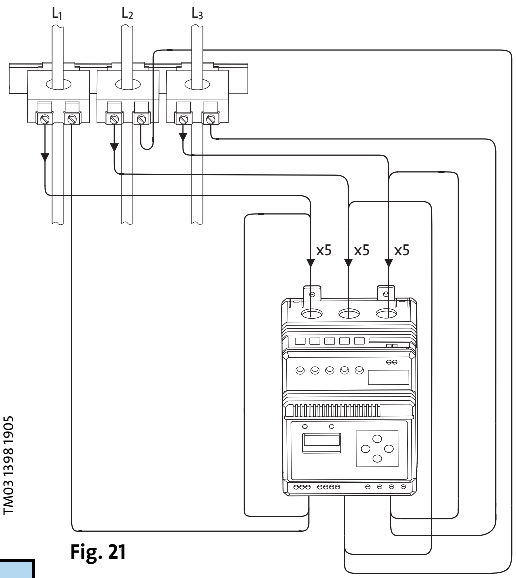


Fig. 21

TM03 0172 4304

External Current Transformers

Product Number	Current Transformer Ratio	Imax.	Pmax.
96095274	200:5	200 A	5 VA
96095275	300:5	300 A	5 VA
96095276	500:5	500 A	5 VA
96095277	750:5	750 A	5 VA
96095278	1000:5	1000 A	5 VA

Table 33

Function

- Phase-sequence monitoring
- Indication of current or temperature
- (user selection)
- Input for PTC/thermal switch
- Indication of temperature in °F or °C (user selection)
- 4-digit, 7-segment display
- Setting and status reading with the R100 or Grundfos GO
- Setting and status reading via the GENIbus.

Tripping conditions

- Overload
- Underload (dry running)
- Temperature (Tempcon sensor, PTC/thermal switch and Pt sensor)
- Missing phase
- Phase sequence
- Overvoltage
- Undervoltage
- Power factor (cos (ϕ))
- Current unbalance.

Warnings

- Overload
- Underload
- Temperature (Tempcon, see section *Setting on control panel*, and Pt sensor)
- Overvoltage
- Undervoltage
- Power factor (cos (ϕ))

Note *In connection with single- and three-phase connection.*

- **Warnings (continued)**
- Run capacitor (single-phase operation)
- Starting capacitor (single-phase operation)
- Loss of communication in network
- Harmonic distortion.

Learning function

- Phase sequence (three-phase operation)
- Run capacitor (single-phase operation)
- Starting capacitor (single-phase operation)
- Identification and measurement of Pt100/Pt1000 sensor

circuit.

Factory settings

Current limit: 0 A
Nominal voltage: 400 V
Class: P (trip delay: 5 seconds) Trip
delay: 5 seconds
Number of phases: 3, non-grounded
(non-earthed) Power-on delay: 5
seconds. Learning function: Active.
Active trip limits
Overload according to class
Underload: - 40 %
Overvoltage: + 20 %Undervoltage: - 20 %
Phase-sequence monitoring Current
unbalance: 10 %
PTC/thermal switch.

Note *The overvoltage and undervoltage trip limits will be deactivated automatically if the temperature monitoring with Tempcon or Pt100/Pt1000 has been set to active.*

Active warnings

Run capacitor, low: - 50 %
Starting capacitor, low: - 50 %.

Input for Pt100/Pt1000

Terminal designation	Description
+	Resistance input.
C	Correction for lead resistance. To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two "C" terminals are to be short-circuited.
C	Correction for lead resistance. To be connected by means of a three-core Pt100/Pt1000 connection, otherwise the two "C" terminals are to be short-circuited.
SH	0 V (screen).

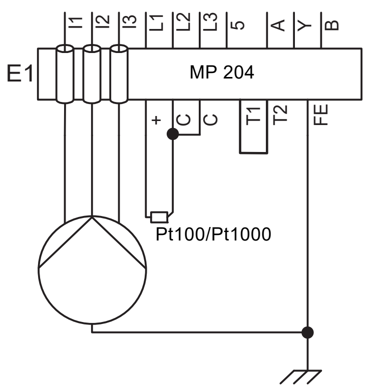


Fig. 22

TM03 1397 2205

Two-core Pt100/Pt1000 connection

Back-up fuses

Maximum back-up fuse sizes which may be used for the MP 204 appear in the table below:

MP204 Fuses

MP 204	Max. Size (A)	Type
Without external current transformer	120	RK5
With 200/5 external current transformer	200	RK5
With 300/5 external current transformer	300	RK5
With 500/5 external current transformer	500	RK5
With 750/5 external current transformer	750	RK5
With 1000/5 external current transformer	1000	RK5

Table 34

At motor currents up to and including 120 A, the cables to the motor can be taken direct through the I1-I2-I3 of the MP 204.

At motor currents above 120 A, current transformers must be used.

Note ***If back-up fuses above 50 A are used, the L1-L2-L3 and "5" to the MP 204 must be protected separately with max. 10 A fuses.***

If current transformers are used, the L1-L2-L3 and "5" to the MP 204 must be protected with max. 10 A fuses.

Input for PTC/thermal switch

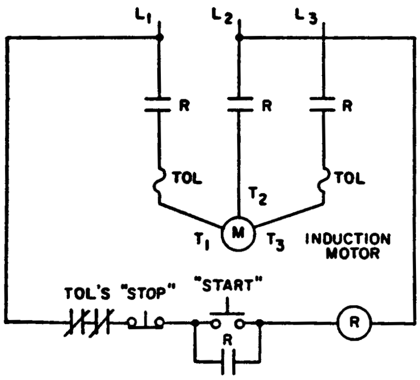
Terminal designation	Description
T1	Connection of PTC/thermal switch
T2	

If not used, short-circuit the PTC input using a wire, or deactivate it with the R100 or Grundfos GO.

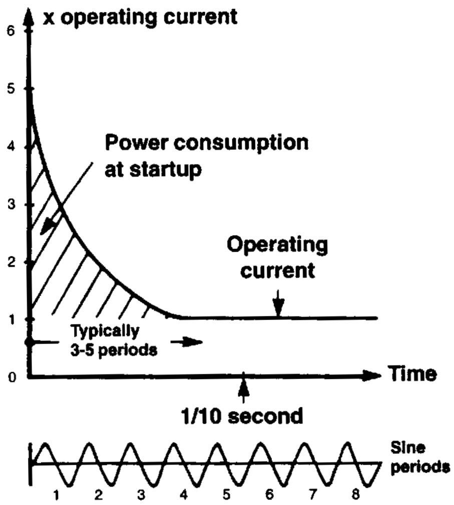
MP204 Wire Size

Stand-alone the MP204 is rated up to 120A maximum. External current transformers (CTs) can be added for extending the current handling up to 1000A. Maximum wire gauge useable with MP204 built in wire path is #2 AWG. External CTs allow for use of cables up to 1.3” in diameter. When using external CTs #16 AWG or larger wire should be used for measuring current. The measuring wires are wrapped thru the MP204 five times for each phase. **See fig. 20.**

Across-the-Line (ATL) Starting Illustration



Typ. ATL Control Schematic

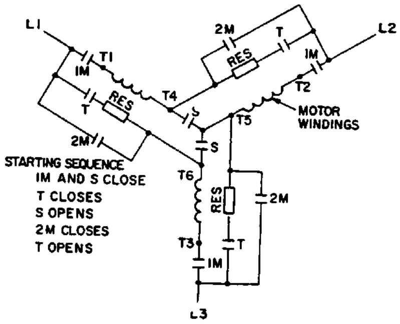


Time vs. Inrush Current

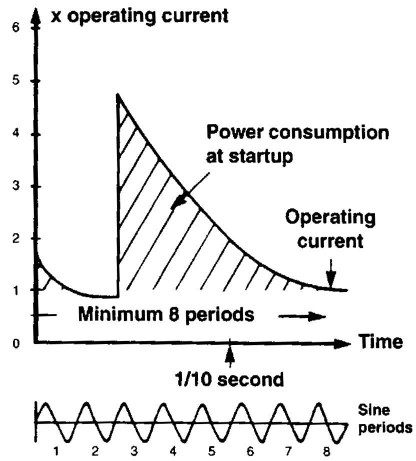
Fig. 23

The ATL starting method will always provide the lowest internal heat generation in the motor and the highest starting torque. Many submersible motor/pump manufactures recommended motors larger than 60 Hp (45kW) be started using some form of reduced voltage/inrush starter, if allowed by the power utility. **The mechanical stresses associate with ATL starting of large horsepower motors can significantly reduce motor life.**

Wye-Delta (YD) Starting Illustration



Typ. Closed-Transition YD Control Scheme

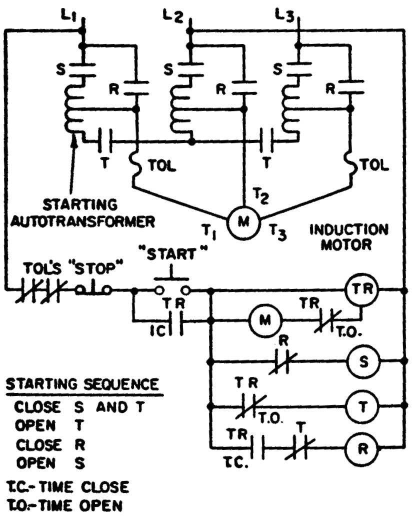


Time vs. Inrush Current

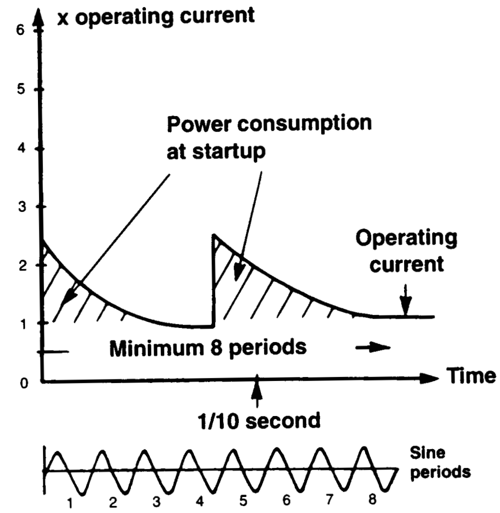
Fig. 24

The YD starting is the most common method for reducing start-up torque and inrush current in Europe. The use of YD starters in the U.S is very limited with submersible motors, as the motor must be specifically configured for the application. Submersible systems employing the YD starting scheme are generally more expensive, as separate power cables and motor leads are required in each installation. Submersible motors configured for YD starting (two motor lead sockets in lieu of one) are more expensive than standard motors.

Autotransformer (AF) Starting Illustration



Typ. Closed-Transition AF Schematic



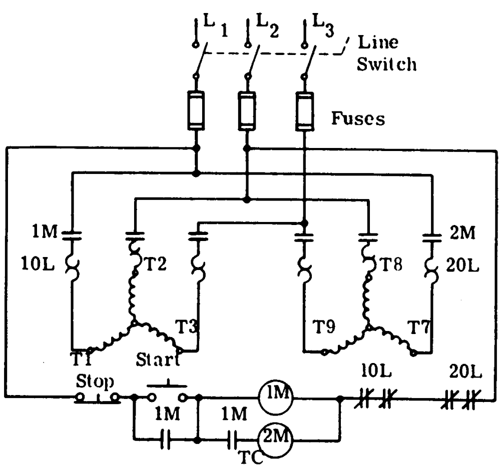
Time vs. Inrush Current

Fig. 25

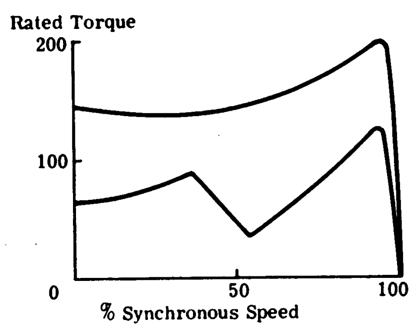
In submersible applications, the tap settings on the AF depends on the percentage of the maximum allowable cable length used in the system. If the cable length is less than 50% of the maximum allowable, either the 65% or 80% taps may be used. When the cable length is more than 50% of the allowable, the 80% tap should be used.

Typical schematic diagram of a part winding starter and the associated torque vs. speed curve.

Part Winding (PW) Starting Illustration



Typ. Half Winding, Part Wind Control Scheme



Torque vs. Speed

Fig. 26

Three Phase Power Supply Unbalance

Three Phase Unbalance is a major cause of shortened motor life and motor failures. It is critical that every Three-Phase motor has the incoming voltage and current going to the motor, checked at start-up, and periodically thereafter. The current unbalance supplying to the motor is what matters to the motor.

There are two types of unbalance that effect the longevity of the motor. Voltage Unbalance and Current Unbalance and Current Asymmetry (amp unbalance). Incoming voltage unbalance is the power measured on each phase coming into the pump panel. Current unbalance is the measurement of the amps on each phase going out of the panel to the motor. Current unbalance between the phases should not exceed 5%. Under 3% should be the goal. Contact your power company to correct the problem if the Current Unbalance between the legs is over 3%. It is clearly visible in induction motors where 1% of voltage unbalance can cause a 6 to 10 % current unbalance. Current is amps.

Helping Action (Motor Derating): Upsize the motor if you are in an area with voltage unbalance. (Motor Derating does not correct the issue of unbalance as you are still sending unbalance to the motor windings). What derating does, is keep the motor temperature down because you are not running the motor at full load, which with unbalance is detrimental to the motor.

NOTE: The positioning of the drop cables can also create current unbalance. If jacketed cables are used, no problems should be expected but should always be checked. If single lead is used it is always recommend placing the Three-Phase conductors on one side of the riser pipe and then have the earth/ground lead diagonally opposite.

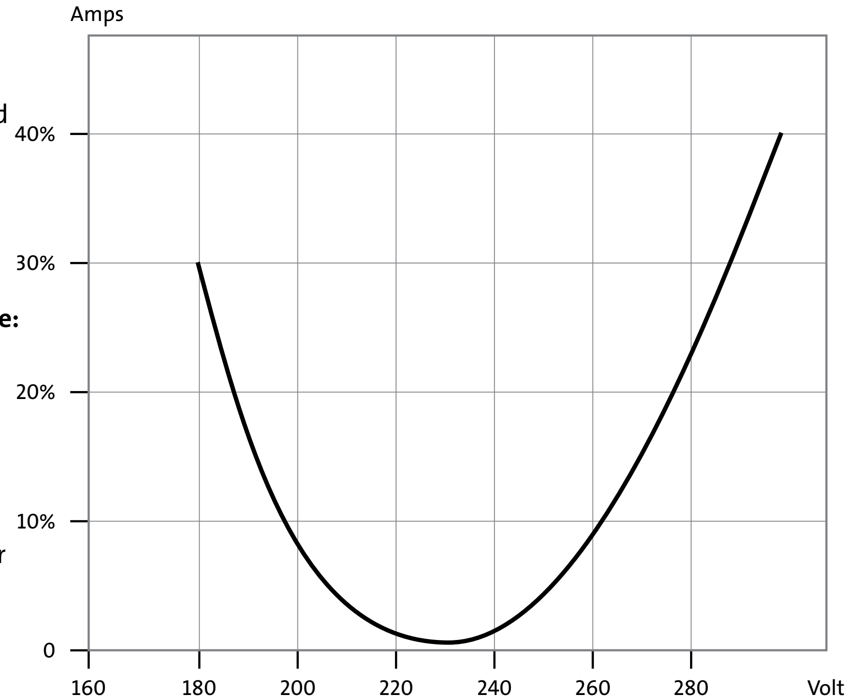
First, we must understand that unbalance can change throughout the day, week, month and/or year. Example is that you may have 1% at 3:00 AM and 11% at 4 PM. Use an MP204 pump protector to help protect the motor. Having a Grundfos MP204 motor protection device running 24/7 is the first defense to help monitor and find these problems before they have a detrimental effect on the motor.

Poor voltage unbalance can create poor current unbalance. Unbalance voltage can highly amplify current unbalance (amps) to increase 6 to 10 times what the voltage unbalance is. Unbalanced voltage will result in increased vibration, excessive heat build-up in the motor, lower starting torque, torque pulsation, mechanical stresses, slower rpm and early motor failure.

Costs associated with voltage unbalance causing motor deterioration and motor failures are wasted energy, unscheduled downtime, early replacement, loss of production, premature motor failure and repairs.

Variable Frequency Drives effects from voltage unbalance. The main areas of a VFD that are effected by the voltage unbalance:

1) The rectifier diode temperature is increased due to asymmetrical current harmonics.
2) Ripples in the DC Bus increase
3) Harmonics are generated on the induction motor terminal
4) A ripple torque in the induction motor is caused via the PWM)pulse width modulator inverter) The impact of deterioration on the motor can be reduced by derating of the motor.



Current variation as a function of over- and undervoltage on a 230 V motor.

Fig. 27

Three Phase Voltage Asymmetry (Incoming Voltage Unbalance) Lifetime Expectation

Three phase voltage/current unbalance is a major cause of shortened motor life and related motor failures. Therefore, it is critical that all three phase motor applications verify voltage/current balance upon startup and periodically thereafter. The voltage/current balance verification should include the incoming power and the motor leads after the motor starter.

There are two different types of unbalance that affect the life of a motor. Voltage unbalance and current unbalance. Incoming voltage unbalance is the power measured on each leg entering the pump panel. Current unbalance is the measurement of amps on each leg exiting the pump panel. It is recommended that the voltage unbalance not exceed 1% as this 1% voltage unbalance will equate to 6% - 10% current unbalance. It is recommended that the current unbalance not exceed 5% and preferable to limit the current unbalance to 3%.

Effect of voltage unbalance on induction motor performance

Voltage unbalance will influence the pumping system in the following ways:

- Increased Vibration
- Excessive heat
- Low starting torque
- Torque pulsation
- Mechanical stresses
- Slower RPM

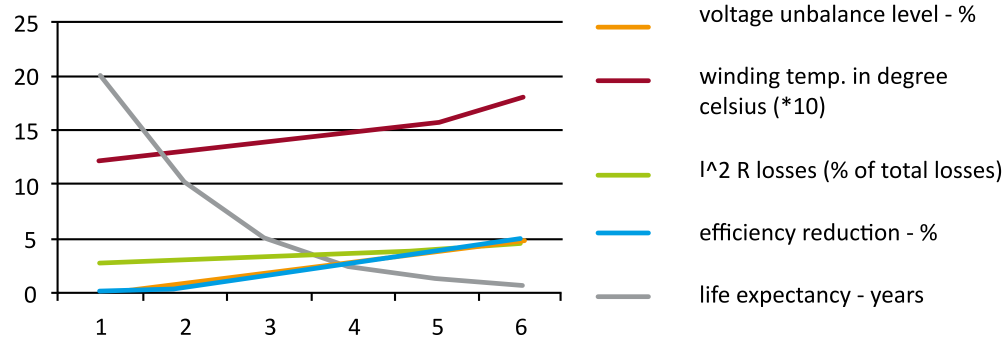


Fig. 28

Reference information for figure above: Plummer, "ASYMMETRY IN DISTRIBUTION SYSTEMS: CAUSES, HARMFUL EFFECTS AND REMEDIES" and reference from Quality Energy, "Eliminate Unbalanced Voltages-Take Action"

Ultimately it is recommended to work with electrical utilities, service providers or internal voltage distribution to obtain a voltage unbalance under 1%. However, at times this may not be possible. In this instance, derating the motor is an option. Derating the motor does not change the fact that the motor is still running in an unbalance condition and the motor windings still are exposed to harmful side effects of that unbalance. Derating the motor allows the motor to run at less than full load thus reducing the harmful effects of heat. **See fig. 29** for derating recommendations.

Motor Derating for Voltage Unbalance

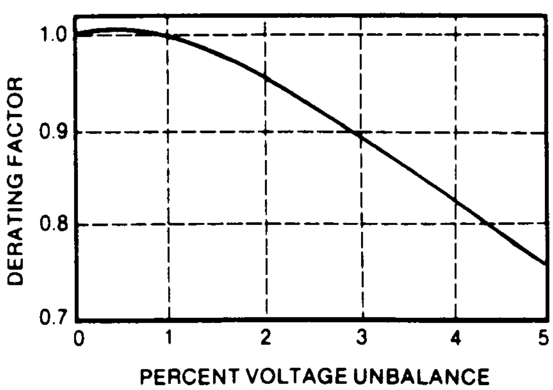
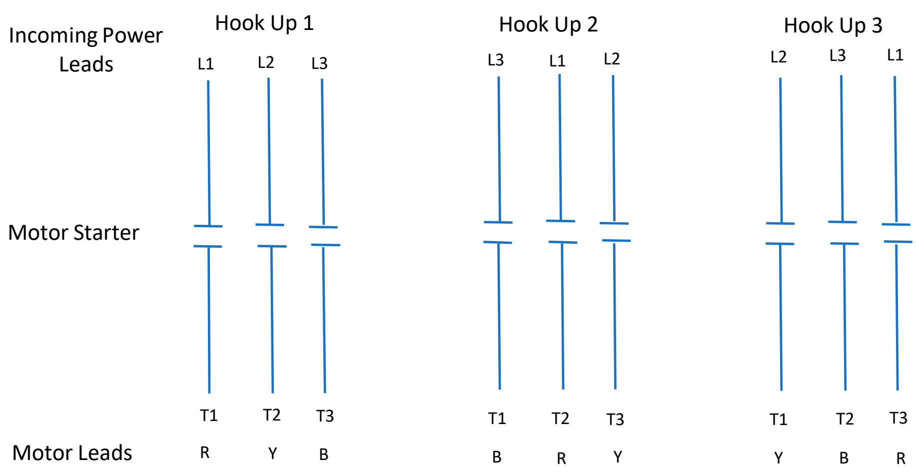


Fig. 29

How to measure Voltage Unbalance

- Measure the incoming voltage between L1 – L2, L1 - L3, L2 – L3 and record the values
- Roll the incoming voltage legs one position to the right, measure and record the new values
- Again, roll the incoming voltage one position to the right, measure and record the final values
- Average the three different measurement groups
- Subtract the lowest voltage measurement from the calculated average
- Divide that subtracted value total by the average to obtain the percentage of voltage unbalance

Voltage Unbalance Calculation



	Hook Up 1	Hook Up 2	Hook Up 3
	L1 - L2 = 465 L1 - L3 = 467 L2 - L3 = 461 Total = 1393	L3 - L1 = 467 L3 - L2 = 467 L1 - L2 = 463 Total = 1397	L2 - L3 = 468 L2 - L1 = 467 L3 - L1 = 467 Total = 1402
Average = Total/3	AVG = 464.3	AVG = 465.6	AVG = 467.3
Subtract Lowest from Average	464.3 - 461 = 3.3	464.3 - 461 = 2.6	468 - 467.3 = 0.7
Voltage Difference / average Volts	3.3 / 464.3 = .007 (.7%) Unbalance	2.6 / 465.6 = .005 (.5%) Unbalance	.7 / 467.3 = .001 (.1%) Unbalance

While all examples are under 1%, best practice would choose Hook Up 3; as it is the lowest voltage unbalance.
Note: 1% Voltage unbalance will equate to 6% - 10% Current Unbalance

Fig. 30

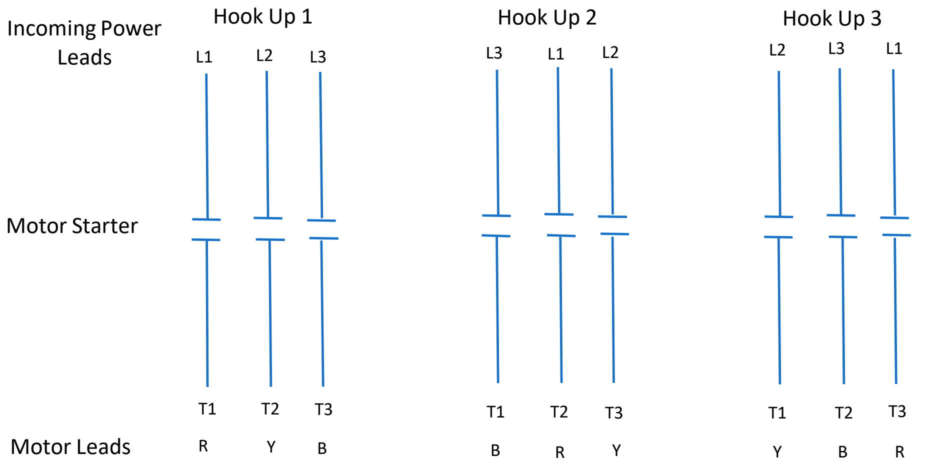
Current Unbalance

Having a low Current Unbalance will give the motor the best environment for longest life. Therefore, it is important to have all three phases of the motor loaded equally. Additionally, it is important that rotation is correct. Rotation can be checked by reversing any two motor leads and determining which connection provides the highest performance.

How to measure Current Unbalance

- Clamp-On measure the amperage on the R, Y, and B leads and record the value
- Roll the R, Y, and B, leads to the right, measure and record the new values
- Again, roll the R, Y, and B leads one position to the right, measure and record the final values
- Average the three different measurement groups
- Subtract the lowest/furthest Amperage measurement from the calculated average
- Divide that subtracted value total by the average to obtain the percentage of current unbalance

Current Unbalance Calculation



	Hook Up 1	Hook Up 2	Hook Up 3
	R = 45 Amps Y = 44 Amps B = 51 Amps	B = 49 Amps R = 44 Amps Y = 44 Amps	Y = 44 Amps B = 45 Amps R = 44 Amps
	Total = 140	Total = 137	Total = 133
Average = Total/3	AVG = 46.6 Amps	AVG = 45.6 Amps	AVG = 44.3
Subtract furthest from Average	51 - 46.6 = 4.4	49 - 45.6 = 3.4	45 - 44.3 = .7
Voltage Difference / average Volts	4.4 / 46.6 = .09 (9%) Unbalance	3.4 / 45.6 = .07 (7%) Unbalance	.7 / 44.3 = .01 Unbalance

In the example above, Hook Up 3 is the best choice.
It is recommended to have a Current Unbalance.

Fig. 31

GRUNDFOS GO

Grundfos GO is a comprehensive platform for remote product control, product selection and product information. It offers intuitive, handheld assistance and access to Grundfos online tools and it saves valuable time for reporting and data collection.

The Grundfos Go Remote app is available from Apple App store and Android market and must be used in conjunction with one of the Mobile Interface devices MI 202, MI 204 or MI 301.

The MI 202 and MI 204 are add-on modules with built-in infrared and radio communication. The MI 202 can be used in conjunction with Apple devices with 30-pin connector (iPhone 4, 4s and iPod touch 4G). The MI 204 can be used in conjunction with Apple devices with lightning connector. The MI301 is a universal bluetooth module that can be used with both Android and Apple devices.

The Grundfos Go Remote concept replaces the Grundfos R100 remote control. This means that all products supported by the R100 are supported by the Grundfos Go Remote.

While connected to a Grundfos product, the following features are available:

- Product dashboard – gives the user a quick overview of the connected product
- Status data – monitor status data from the Grundfos product
- Alarms and warnings – see detailed alarm information with timestamps
- Configuration/commissioning
- Create installation report in pdf format
- Read/write profiles – copy configuration from one product to another
- Supports 28 languages

PRODUCT INFORMATION AND SELECTION FEATURES:

- Search product by: Number, Name, or QR code
- Size a product (Heating, Air-conditioning, Pressure boosting & Wastewater)
- Catalog
- Replace product
- Compare products
- Product view
- Projects view
- Projects
- Favorites

Phase Converters

For locations where the utility source is single-phase and the desired power is three-phase, a phase converter can be used.

All phase converters have difficulty balancing output voltage in changing load conditions like those seen in submersible motor applications. Balanced voltage supply is important in order to avoid elevated motor operating temperatures and reduced horsepower performance. If a phase converter must be used, electronic, solid-state designed converters are recommended.

Guidelines for using a phase converter:

- **Avoid loading the motor to rated horsepower - Do not load into service factor**
- **Ensure 3 ft/sec flow past the motor - Utilize motor shroud where possible**
- **Current unbalance between the phases (legs) should not exceed 5%. Under 3% should always be the goal. Contact the power company to correct the problem if the Current Unbalance between the legs is over 3%**
- **Input wire gauge must be sized to accommodate single-phase input current**
- **Review voltage drop when determining wire gauge. Voltage drop is dependent on wire length and gauge**
- **Use time delay fuses or circuit breakers in pump panel**
- **Review factory default motor overload relay (trip current adjustment) setting**
- **Use a Grundfos MP204 motor protector. Can be used on the input power side of solid-state phase converters and drives.**

Reduced Voltage Starters

Locations with weak utility power may require the usage of a reduced voltage starter to limit voltage sagging. Reduced voltage starters can reduce starting torque and mechanical stresses on pump/motor shafts, couplings and piping. Water hammer issues cause by rapid acceleration of water during start-up can also be reduced by using reduced voltage starters.

Two types of reduce-voltage starters are recommended for use with submersible motors:
1) Autotransformer (stepdown type transformer)
2) Electronic solid-state (Soft start). Both reduce motor input voltage during startup.

Autotransformers reduces the motor voltage by a fixed ratio (step). Taps provided on the transformer are usually rated at 50%, 65%, and 80% of line voltage (**See Table 35** for approximate power values). It's recommended when sizing a reduced-voltage started, use a Closed-Transition design, as this design keeps the motor connected to power through the start process.

% of Full Voltage Values		
% Voltage Tap	% Motor Inrush Current	% Starting Torque
80	80	64
65	65	42
50	50	25

Table 35

In submersible applications, the tap settings depends on the percentage of maximum allowable cable length used in the system. If the cable length is less than 50% of the maximum allowable, either the 65% or 80% taps may be used. When the cable length is more than 50% of the allowable, the 80% tap should be used.

Always review factory default settings for time delay transition between reduced and full voltage power. Submersible motors require full voltage within 3-seconds to prevent excessive radial load and thrust bearing wear.

Electronic solid-state starters provide smooth, step-less acceleration and deceleration of submersible motors from zero to full speed over an adjustable time range. Acceleration and deceleration ramp times should be limited to no more than 3 seconds with a minimum voltage setting of 55%. In general, it is recommended to install a bypass contactor in conjunction with soft starter so the motor runs in across-the-line condition during operation.

Grundfos MS/MMS submersible motors can be used with variable frequency drives (VFD) provided the following guidelines are followed.

Variable frequency drives inherently produce voltage spikes due to differences between cable length impedance and motor surge impedance. Voltage spikes in excess of 850V may exceed motor insulation protection, causing premature motor failure. Known as, Reflected Wave Phenomenon this voltage spiking is common in applications where there are long distances between the VFD and motor, typical of submersible pump applications.

In **Fig. 32**, the voltage (Vuv) graph shows a common VFD output square waveform with voltage spiking rather than a desired sinusoidal waveform. The current waveform (Iu) while more sinusoidal in appearance, still has damaging spikes.

Voltage (V) and Current (I) at Motor without Sine-Wave Filter

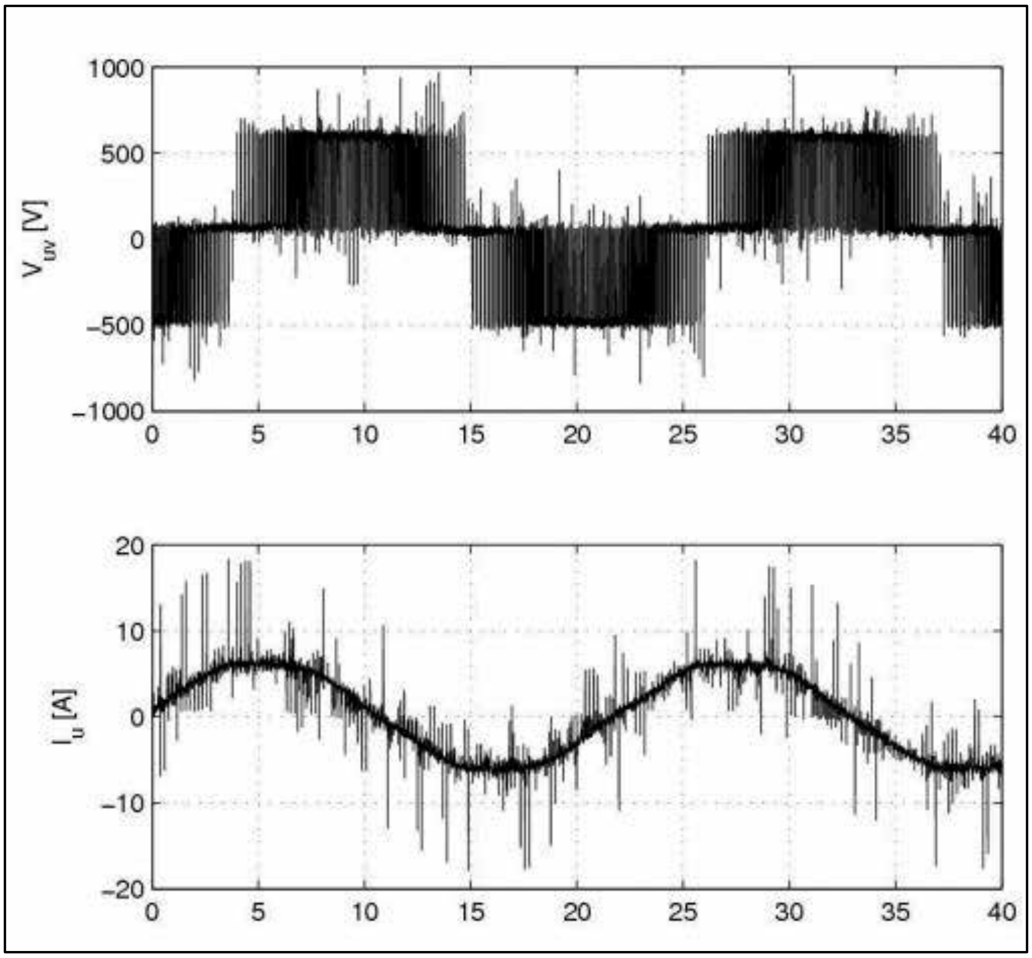


Fig. 32

Sine-wave filters are designed to provide the desired smooth sine-wave VFD output, ideal for the operation of a submersible motor. Output filters are used to reduce the impedance differences between cable and motor. Therefore, reducing voltage spikes on motor windings, insulation components, and for decreasing acoustic noise from the VFD.

When a sine-wave filter is applied properly between the VFD and motor, the waveforms are nearly smooth. **See Fig. 33 and 34**.

Voltage (V) and Current (I) at Motor with Sine-Wave Filter

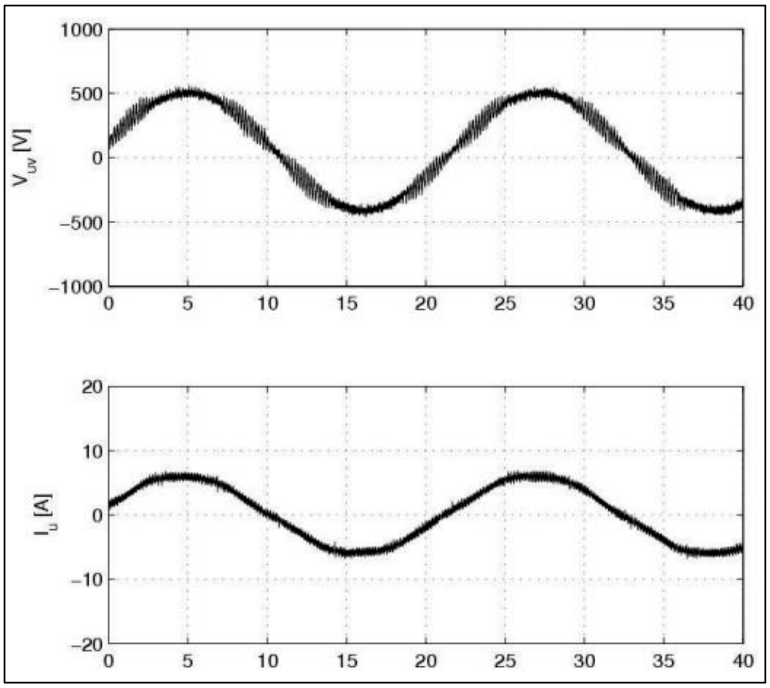


Fig. 33

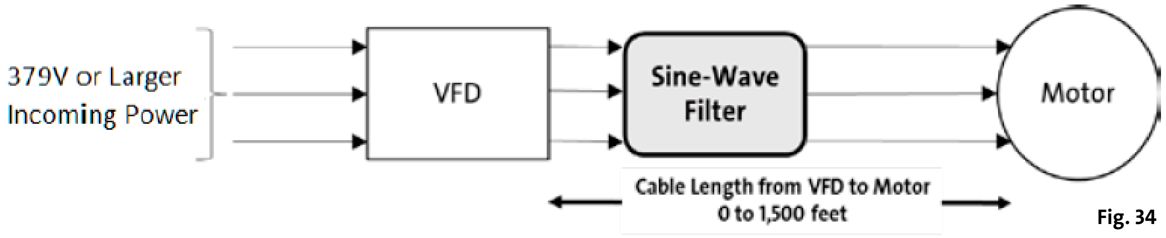


Fig. 34

To ensure warranty considerations, Grundfos recommends installing a sine-wave filter or equivalent type RLC filter when a frequency converter (VFD) is used on a submersible pump application if any of the following conditions are met:

1) Motor name plate voltage is over 379V.
2) Drive uses pulse width modulation (PWM) and/or IGBT-BJT switches .
3) VFD voltage rise-time less than 2 msec (NEMA MG 1-2011).
4) Peak voltage at motor terminals exceed 850 volts..
5) Power cable length from VFD output to submersible motor terminals is 0 to 1,500 ft.
   a. For applications with cable length greater than 1,500 ft., contact Grundfos Pumps when using a Grundfos drive.
   b. If not a Grundfos drive, contact drive manufacturer for acceptable cable lengths.

Variable Frequency Drives

If not using a Grundfos VFD/sine-wave filter combination, the drive manufacturer will need the following information to ensure proper sine-wave filter type and size. All items are required:

1) VFD model

2) Type of application

3) Carrier frequency used

4) Motor nameplate voltage

5) Motor nameplate service factor Amps

6) Motor insulation rating

7) Cable type, size, and length from the drive output to the motor terminals

Notice:

1) RL only or dv/dt types of filters are not considered equivalent to sine-wave filters.

2) The use of line-side filter on power entering the drive does not replace the need for additional output or load-side sine-wave filter.

To ensure proper motor cooling, the following is recommended:

1) Minimum VFD frequency set to provide no less than required velocity in feet per second past the motor:
a. 4-inch motors 0.25 ft./sec
b. 6 to 12-inch motors 0.50 ft./sec

2) Supply voltage within the +6% and -10% from nameplate (example single voltage rated motor of 460V, would be minimum of 414V to maximum 487V). For 60Hz rated multi-voltage motors, the voltage variant of 440/460/480 volt will function within minimum of 396V to maximum 509V.

Recommended VFD set point values:

1) Volt to Hz profile should be set to variable torque, square law, and not set to linear.

2) Voltage and current unbalance between phases limits:
a. Maximum current unbalance 5% **(max with not over 3% recommended)**

3) Motor protection set point values:
a. Maximum input current – rated at name plate current
b. Overload trip protection set at 115% of systems operating current
c. Overload trip protection equal to or faster than NEMA Class 10
d. Underload protection is normally set at 80% of normal system load (current)

4) Permissible frequency range 30Hz to 60Hz on Grundfos submersible motors.

a. Always check with other manufacturers as some have a different minimum frequency on specific motors.

5) VFD acceleration and deceleration should be set to no more than 3-seconds:
a. 0 - 30Hz 1 seconds maximum
b. 30 - 0Hz 1 seconds maximum

6) Drive carrier frequency should be set as low as possible – Not above 4 kHz - Not below 1 kHz.

a. When using a sinewave filter always check with filter manufacturer for Drive Carrier Frequency setting with a specific drive.

WARNING: ELECTRICAL TEST SHOULD ONLY BE CARRIED OUT BY A PERSON PROPERLY TRAINED AND LICENSED FOR THIS TYPE OF WORK

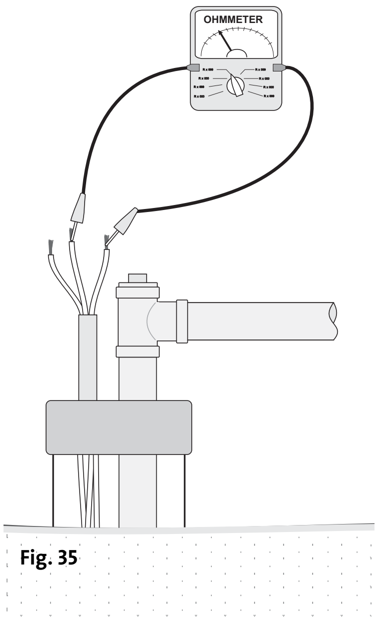


Fig. 35

Winding Resistance Instructions:

1. Turn the **POWER OFF**.
2. Disconnect all electrical leads to the drop cable.
3. Set the scale selector on the ohmmeter to R x 1 (if you expect ohm values under 10) or R x 10 (for ohm values over 10).
4. Touch the leads of the ohmmeter to two motor leads:
   Single Phase Motors
   Touching the leads of the ohmmeter to the black and yellow leads will measure the main winding's resistance for Grundfos 402 motors. The red and yellow leads will be the start winding's resistance.
   Three Phase Motors
   Touching the leads of the ohmmeter to any two leads will measure that winding's resistance. Repeat for all three possible lead combinations.
5. Watch the ohmmeter scale and record this figure. Subtract the ohm resistance for the drop cable from the number. Compare the remaining figure with the one shown in the Motors section if the motor has been pulled.

If:	**Then:**
Ohm values are normal	Motor windings are okay
One ohm value is less than normal	Motor winding may be starting to short
One ohm value is greater than normal	Motor winding may be starting to open
Some ohm values are greater than normal (>25%) and some are less than normal (± 25%)	The leads may be connected incorrectly, or have a break in the insulating jacket

Insulation Resistance (lead-to-ground)

To check the insulation resistance of the drop cable, splice, and motor leads, a megohmmeter is required.

Instructions:

1. Turn the **POWER OFF**.
2. Disconnect all electrical leads to the drop cable.
3. Set the scale selector on the megohmmeter (Ohm meter / volt meter) to R x 100, touch its leads together, and adjust the indicator to zero.
4. Touch the leads of the megohmmeter to each of the motor leads and to ground (i.e. L_1 to ground; L_2 to ground, etc.). The well casing, if made of steel, makes an excellent ground.

Evaluation: In general, any ohm value above 1,000,000 ohms indicates everything is OK. The following table gives more specifics.

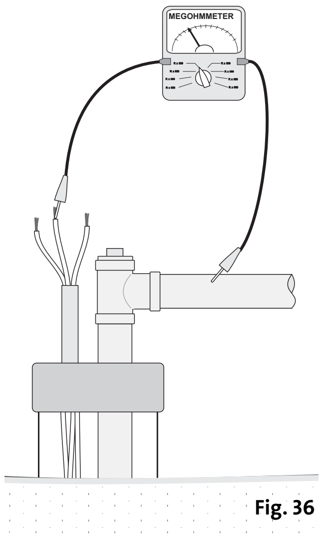


Fig. 36

Insulation Resistance

Insulation resistance in a submersible pumping system is a measure of the motors and/or cables ability to withstand normal voltage and surge voltages, without breakdown and failure. An "adequate" level of insulation resistance is not a constant value, but depends on the installation voltage and conditions, and whether the measured resistance is lowered by a specific weak point or by widely distributed conductance such as in cable insulation material itself. For this reason, values for acceptable resistance cannot be specific.

Insulation Resistance Measurements should be taken at the time of initial motor installation and periodically thereafter. In deep set submersible installations, measurements should be taken throughout the installation process, to detect potential cable insulation/connection damage before the unit is completely installed. Table 38 describes the condition of the insulation system for a submersible motor system of 600V or less based on megohmmeter (megger) readings.

Insulation Resistance (Megger Readings) & Motor Condition

Condition of Motor and Leads	OHM Value	MEGOHM Value
A new motor (without drop cable).	20,000,000 (or more)	20.0 (or more)
A used motor which can be reinstalled in the well	10,000,000 (or more)	10.0 (or more)
MOTOR IN WELL. Ohm readings are for drop cable plus motor.	OHM Value	MEGOHM Value
A new motor in the well.	2,000,000 (or more)	2.0 (or more)
A motor in the well in reasonably good condition.	500,000 - 20,000,000	0.5 - 2.0
A motor which may have been damaged by lightning or with damaged leads. Do not pull the pump for this reason.	20,000 - 500,000	0.02 - 0.5
A motor which definitely has been damaged or with damaged cable. The pump should be pulled and repairs made to the cable or the motor replaced. The motor will not fail for this reason alone, but it will probably not operate for long.	10,000 - 20,000	0.01 - 0.02
A motor which has failed or with completely destroyed cable insulation. The pump must be pulled and the cable repaired or the motor replaced.	less than 10,000	0 - 0.01

Note: Table is applicable to motor nameplate voltage ratings of 600V or less.

Table 36

Insulation Resistance DC Test Voltages

Rated Motor AC Voltage	Recommended DC Test Voltage
600V and less	500 VDC
601V to 1000V	500 to1000 VDC
1001V and up	500 to 2500 VDC

Table 37

Note: Values are based on copper conductors. Aluminum conductor resistance can be calculated by: Multiply the ohm values from the chart by 1.64.

Copper Wire Resistance
(DC Resistance in Ohm/100 ft. @ .75 °C / 33.35 °F Cond. Temp.)

Wire Size		
AWG	MCM	Ohms
14	-	.324093
12	-	.203820
10	-	.128178
8	-	.080628
6	-	.050712
4	-	.031862
2	-	.02006
1/0	-	.012648
2/0	-	.010001
3/0	-	.007931
4/0	-	.006290
-	250	.005324
-	300	.004436
-	350	.003803
-	400	.003327
-	500	.001774
-	600	.002218
-	700	.001901
-	750	.001774
-	1000	.001330

Table 38

Trouble Shooting And Maintenance
Identifying conductors on single phase, 3-wire application:

- With power off, take ohm readings, leg to leg. Readings should correspond with motor specifications
- You will have one combination of wires with the highest Ohm reading, those two wires will be the Black and Red
- Measure the third wire (Yellow) with the other two, you will have a high and low
- Low measurement is the Black/Yellow combination
- High measurement is the Red/Yellow combination
- Confirm wire markings by: B/Y measurement added to R/Y measurement = B/R measurement

Supply Voltage Check (No load)

To check the supply voltage, use a voltmeter (or amprobe) with the power on.

Instructions

1. Set the voltmeter to the highest scale
2. Remove the cover of the control box: BE CAREFUL -- POWER IS STILL BEING SUPPLIED TO THE CIRCUIT. Do not touch the voltmeter leads together while they are in contact with the power lines.
3. Touch the ends of the voltmeter leads as follows:

Single Phase Motors
Touch one voltmeter lead to each of the lines supplying power to the control (L1 and L2 , or L1 and N for 115V circuits). →

Three Phase Motors
Touch a voltmeter lead to the following:

- Power leads L1 and L2
- Power leads L2 and L3
- Power leads L3 and L1
- Two fuses
- Two contact points
- Two heaters

} *These tests should give a reading of full line voltage.*

Checking Single Phase Power

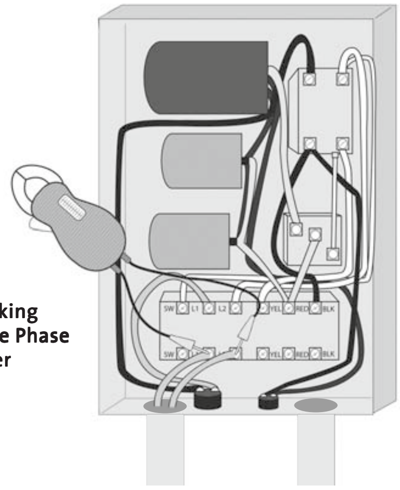


Fig. 37

Evaluation

When the motor is under load, the voltage should be -10% and +6% of the nameplate voltage. Any variation larger than this can cause damage to the motor windings and should be noticeable as a high amp problem.

If The Motor Nameplate Reads:		Then the minimum and maximum voltage should be:	
		Minimum	Maximum
115V	(single phase)	105 volts	121 volts
208V	(single or three phase)	188 volts	220 volts
230V	" "	210 volts	243 volts
460V	(three phase)	414 volts	487 volts
575V	" "	518 volts	609 volts

Any variations outside these specifications may indicate a poor electrical supply. The motor should not be operated under these conditions. Contact your power supplier to correct the problem or change the motor to one requiring the voltage you are receiving.

Operation and maintenance Service and installation should be performed by a qualified service representative.

1. Overload, if equipped, 1.5 Hp and up:
(Push reset button to make sure contacts are closed).

– Ohmmeter setting: (Rx1).
– Terminal connections: ohmmeter leads to overload terminals.
– Ohmmeter reading: should not be over 0.5 ohms.

2. Capacitor (disconnect one lead from each capacitor prior to checking).

– Ohmmeter setting: (Rx1000).
– Terminal connections: individual capacitor terminals.
– Ohmmeter reading: pointer should swing toward zero then drift back toward infinity.

3. Relay coil (disconnect lead from terminal 5).

– Ohmmeter setting: (Rx1000).
– Terminal connections: "5" and "2" on relay.
– Ohmmeter reading: 4500-7000 ohms.

4. Relay contact (disconnect lead from terminal 1).

– Ohmmeter setting: (Rx1).
– Terminal connections: "1" and "2" on relay.
– Ohmmeter reading: should be zero.

5. Magnetic contactor only, if equipped, DLX box only (disconnect 1 coil

– Ohmmeter setting: (Rx1000).
– Check coil resistance: 1000 - 1400 ohms.
– Remove contact cover and inspect contacts.

Checking the Relay

(SINGLE-PHASE CONTROL BOXES ONLY)

To check the electrical condition of the relays on single phase control boxes, an ohmmeter is required.

Specific instructions for checking the relay differ from control box to control box. Refer to the inside cover of your control box.

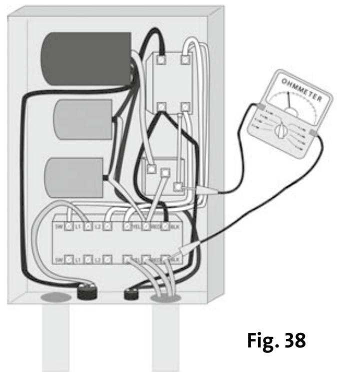


Fig. 38

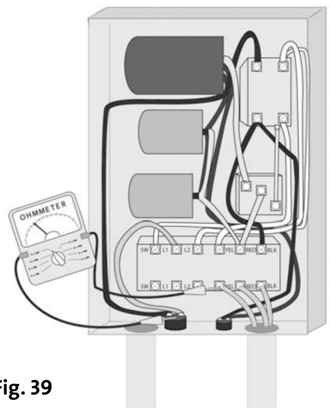


Fig. 39

Overload Protection

To check the electrical condition of the thermal overloads, an ohmmeter is required.

Instructions:

1. Turn the **POWER OFF**.
2. Set the scale selector on the ohmmeter to R x 1.
3. Touch one of the ohmmeter leads to an overload protector and one to terminal 1, then terminal 3. Repeat for each overload protector.

Evaluation:

If the ohm values are 0.5 ohms or less, the overload protectors should still be functional. If not, they should be replaced.

Capacitor Check

To check the condition of any capacitor on single phase motors, use an ohmmeter.

Instructions:

1. Turn the **POWER OFF**.
2. Disconnect the capacitor from the power source.
3. Discharge the capacitor by touching its leads together.
4. Set the scale selector on the ohmmeter to R x 100K.
5. Connect the leads of the ohmmeter to the black and orange wires of the capacitor.
6. Watch the ohmmeter scale.
7. Disconnect one lead from the capacitor for approximately 30 seconds. The needle should return to the last reading taken.

Evaluation

If the capacitor is OK, the needle should swing towards zero and then float back towards infinity (∞). If the needle drops and remains at zero, the capacitor is probably shorted. If the needle remains at a high value, there is an open circuit.

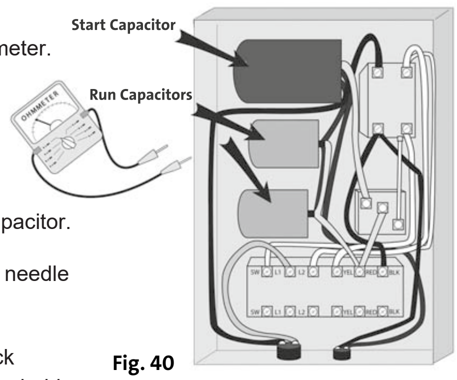


Fig. 40

CAUTION: This test may indicate a good capacitor even though it may have lost some capacitance, making the motors run noisy or draw high amps. To safeguard against this, the capacitor can be checked with a capacitor meter.

Single-Phase Wiring Diagrams for Grundfos 3-Wire Control Boxes

Wiring for 0.5 to 1 Hp models

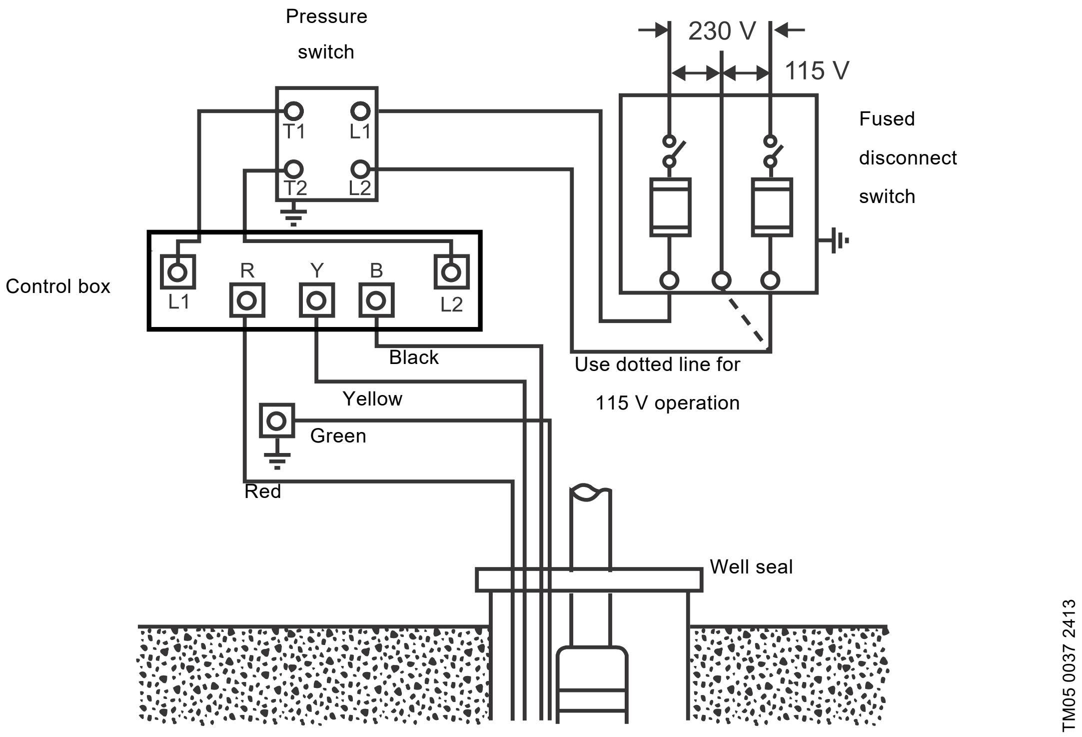


Fig. 41

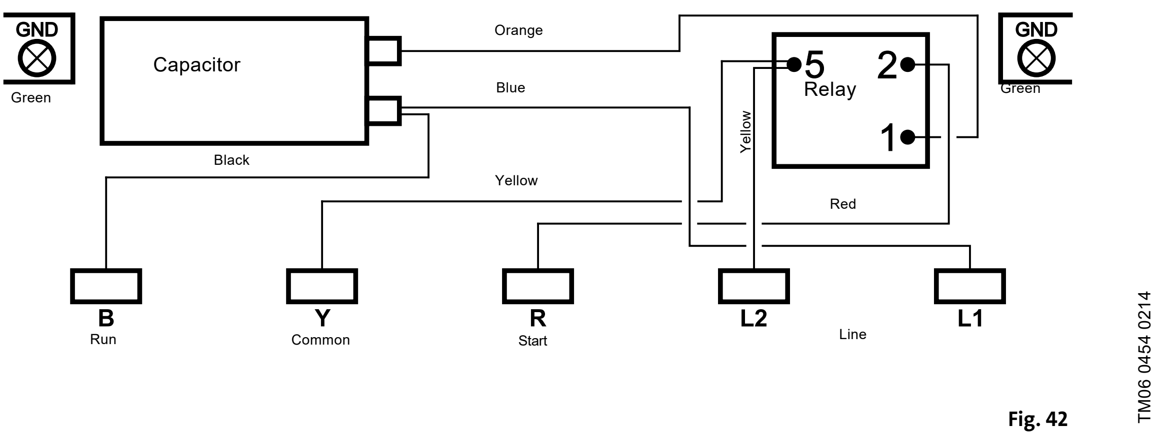


Fig. 42

3-Wire Control Box Wiring Diagrams - Single-Phase

Wiring for 1.5 Hp models (Standard)

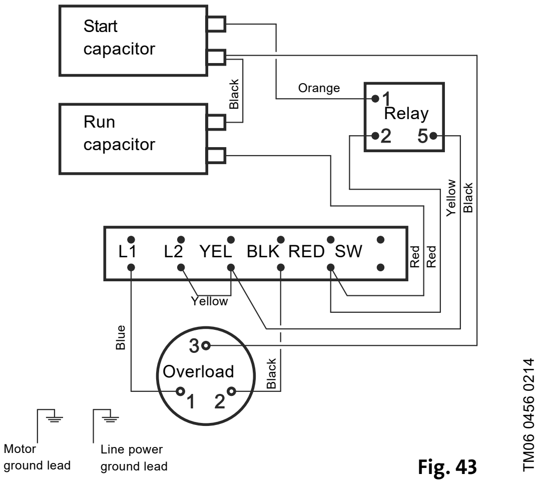


Fig. 43

Wiring for 1.5 Hp models (Deluxe)

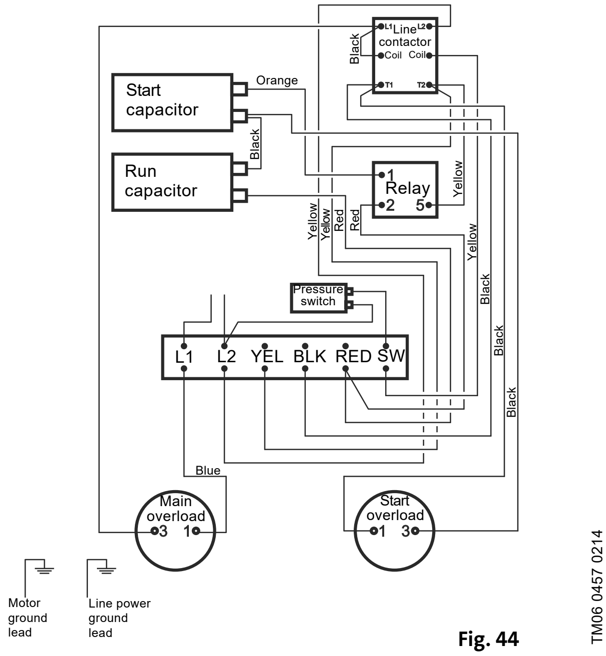


Fig. 44

Wiring for 2 and 3 Hp models (Standard)

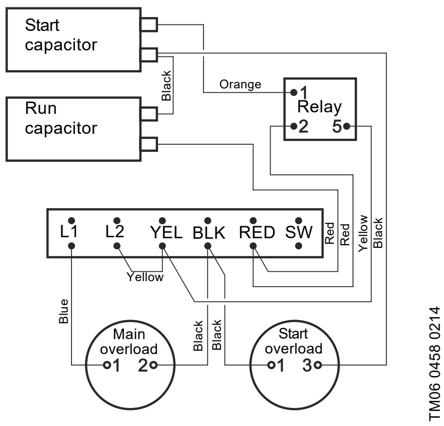


Fig. 45

Wiring for 2 and 3 Hp models (Deluxe)

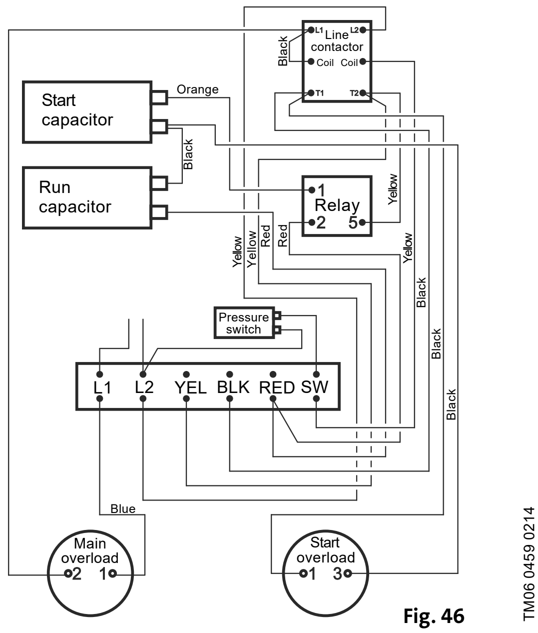


Fig. 46

3-Wire Control Box Wiring Diagrams - Single-Phase

Wiring for 5 Hp models (Standard)

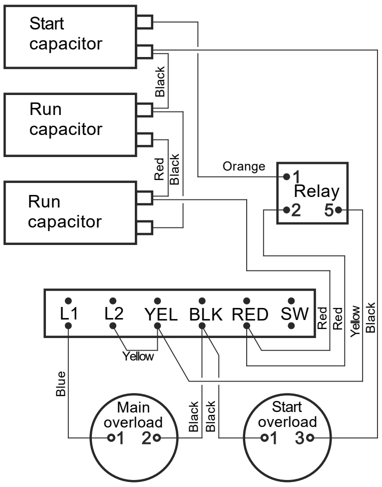


Fig. 47

Wiring for 5 Hp models (Deluxe)

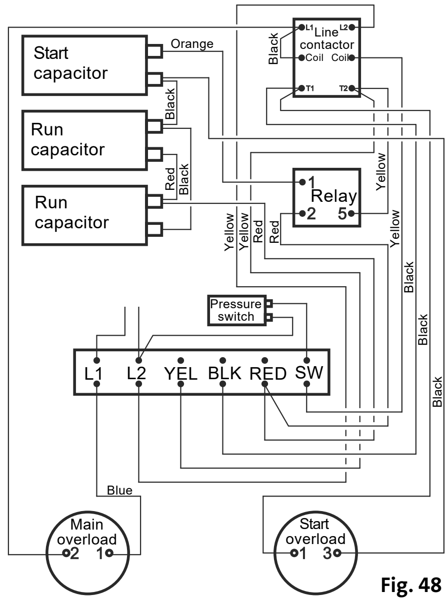


Fig. 48

TM06 0461 0214

WIRING DIAGRAMS BELOW & ON NEXT PAGE FOR NEW PRODUCT *(TO BE RELEASED IN 2018)*

Wiring for 3 Hp models (Deluxe)

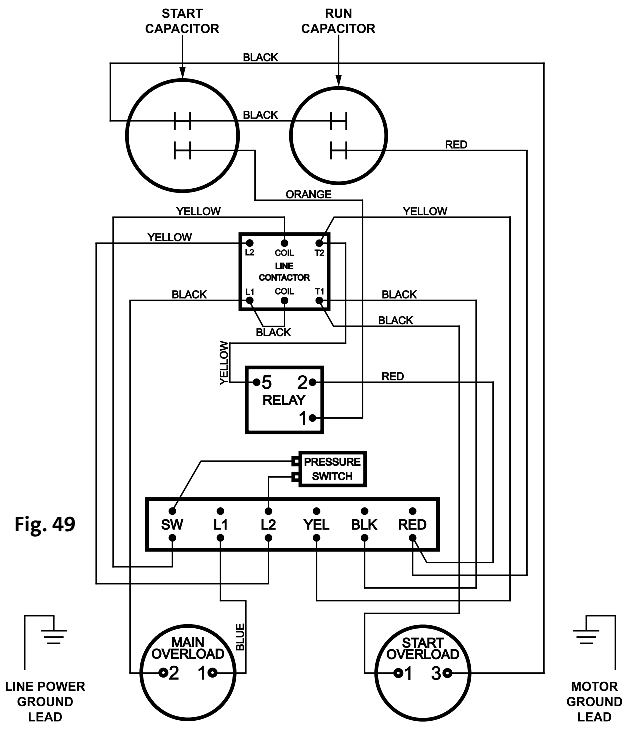


Fig. 49

Wiring for 5 Hp models (Deluxe)

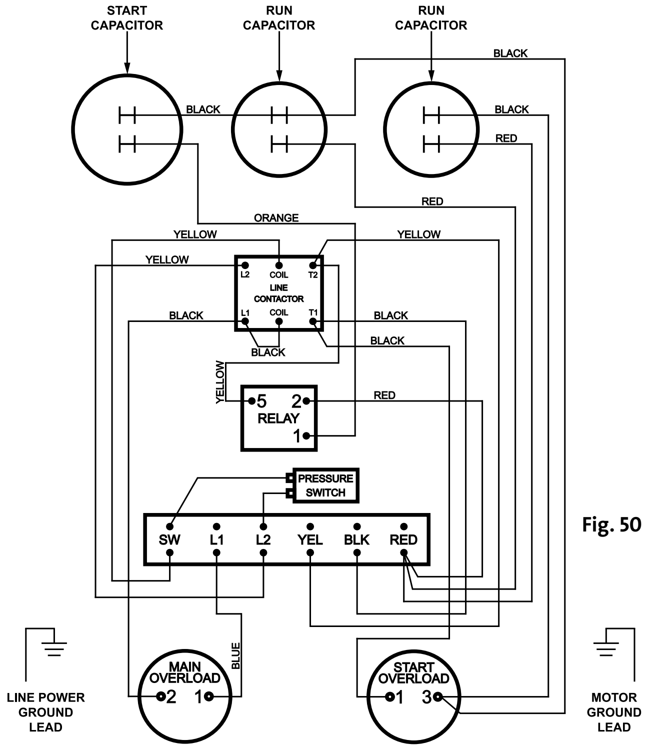


Fig. 50

3-Wire Control Box Wiring Diagrams - Single-Phase

Wiring for 7 1/2 Hp models (Deluxe)

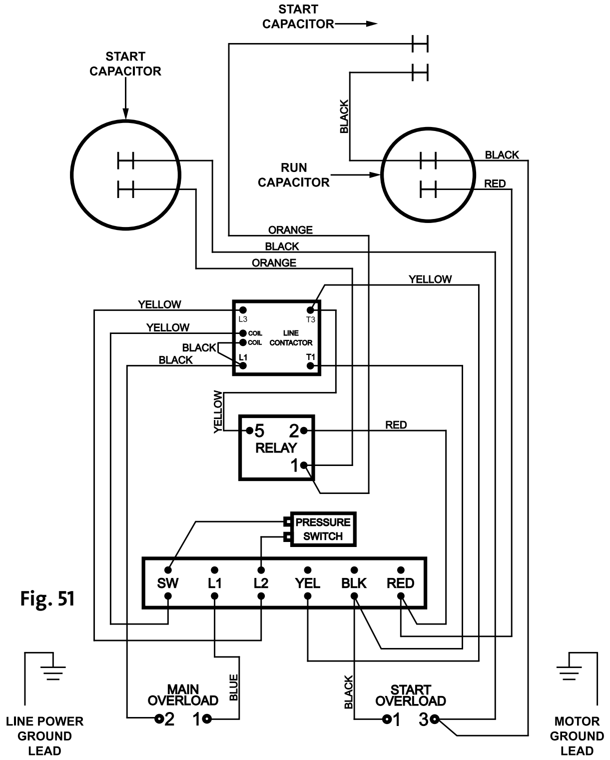


Fig. 51

Wiring for 10 Hp models (Deluxe)

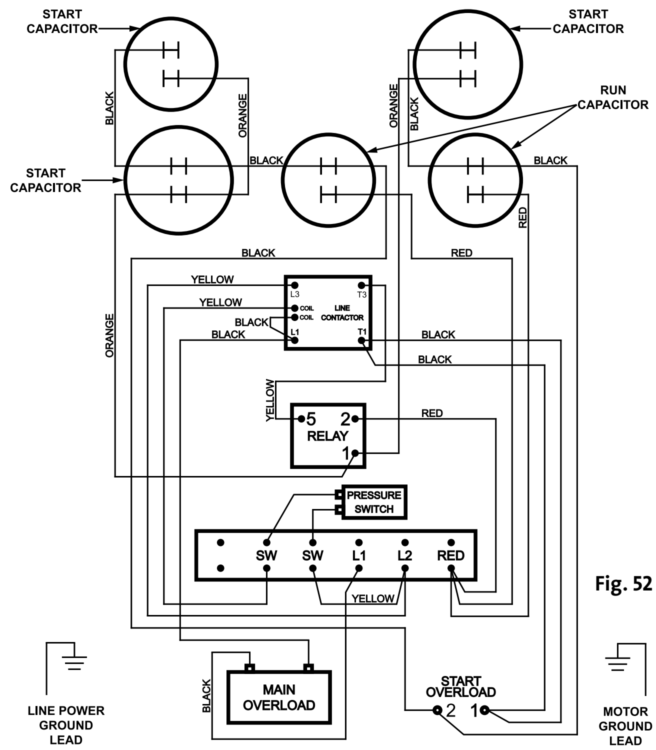


Fig. 52

Wiring for 15 Hp models (Deluxe)

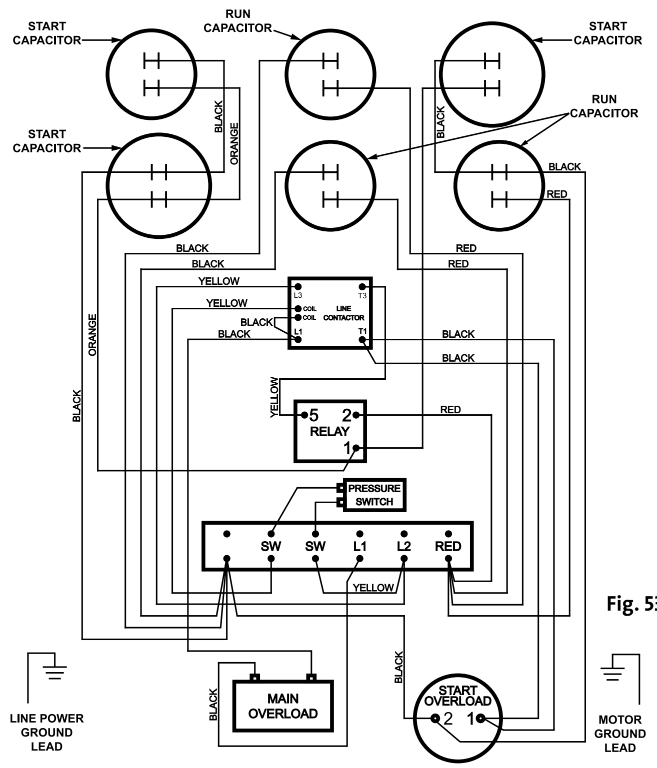


Fig. 53

Replacement Components for Grundfos Control Boxes: Deluxe, SA-SPM5 and SA-SPM6

HP	Type	Volts	PH	Hz	Control Box Material Number (Sold In Singles)	Control Box Material Number (10-Pack Bundles)	Material Number For Reference	Start Capacitor Material Number	Run Capacitor Material Number	Relay Material Number	Main Circuit Thermal Overload Material Number	Start Circuit Thermal Overload Material Number
1/2	STD	115	1	60	-	98821580	98315240	98315282	-	98673361	-	-
1/2	STD	230	1	60	-	98821631	98315251	98315278	-	98315271	-	-
3/4	STD	230	1	60	-	98821632	98315252	98315279	-	98315271	-	-
1	STD	230	1	60	-	98821633	98315253	98315280	-	98315271	-	-
1-1/2	STD	230	1	60	98315254	-	-	98315280	98315274	98315271	91126321	91126324
1-1/2	DLX	230	1	60	98315255	-	-	98315280	98315274	98315271	91126321	91126324
2	STD	230	1	60	98315256	-	-	98315280	98315275	98315271	91126321	91126324
2	DLX	230	1	60	98315257	-	-	98315280	98315275	98315271	91126321	91126324
3	STD	230	1	60	98315258	-	-	98315281	98315277	98315272	91126322	91126325
3	DLX	230	1	60	98315259	-	-	98315281	98315277	98315272	91126322	91126325
5	STD	230	1	60	98315260	-	-	98315283	98315276	98315272	91126323	91126326
5	DLX	230	1	60	98315261	-	-	98315283	98315276	98315272	91126323	91126326

Table 39

DLX: Deluxe Control Box (DLX) indicates magnetic starter included in addition to Standard Control Box (STD).
SA-SPM5 and SA-SPM6 relays and capacitors are dimensionally different and are not interchangeable.
Main Circuit and Starter Circuit Thermal Overloads fit both SA-SPM5 and SA-SPM6. They are interchangeable.

Applications

SQE Pump/Motor

The SQE, when coupled with a CU301 control, is the only constant pressure pump on the market fully equipped with built-in electronic controls which allow for advanced computer controlled performance and state of the art protection features including sophisticated diagnostics.

Main Applications: Domestic water supply, irrigation, pressure and water boosting

Features:
Soft Start - Prevents water hammer and electrical stress on the service main and the motor

High Starting Torque – even at low supply, the SQE delivers a reliable water supply

Over and under voltage protection – protects the motor from unstable voltage supply by reducing speed or stopping the motor

Dry Run Protection – stops and prevents the pump from damage
Please refer to the Grundfos SQE Data Booklet and Installation & Operating instructions for more detail.

SQE

It is safe to operate the SQE with a generator. The generator must be sized 50% above the P1 (Input power) values of the pump.

Motor (HP)	Minimum Generator Size (Watts)	Recommended Generator Output (Watts)
1/2	1200	1500
3/4	1900	2500
1	2600	3200
1-1/2	2800	3500

Table 40

SQE System

SQE Fuse and Cable Size Recommendations

Motor Rating			Copper Wire Size (AWG)						
Volts	Hp	Amps	14	12	10	8	6	4	2
115	1/2	12	140	220	360	550	880	1390	2260
230	1/2	5.2	640	1000	1660	2250	4060	-	-
	3/4	8.4	400	620	1030	1580	2510	3970	-
	1	11.2	300	460	770	1190	1890	2980	4850
	1.5	12	280	430	720	1110	1760	2780	4530

Table 41

Note - Gray highlighted values do not apply when using a CU301 as its maximum recommended cable length is 650 ft.

Generator Sizing:

Generator sizing is based on the following formula.

1. Input Max Voltage calculation = Highest Rated Voltage +/-10%.

Example: 200-240V = 240 x 1.10 = 264 Input Max Voltage

2. Drive KVA Rating calculation = Drive Input Max Voltage x Drive Output Max Current (Amps).

Example: 264 x 10.6 = 2798 Drive KVA Rating

3. Factor to Generator = Drive KVA Rating x 2.5 Factor = Minimum Generator Size.

Example: 2798 Drive KVA Rating x 2.5 Factor = 7000 Watt (7 kW) Generator

CU331 SP Control

CU331SP

The CU331SP can be supported by a generator which must be electronically controlled/stabilized.

Motor (Hp)	CU331SP Rated Input Voltage	CU331SP Input Max Voltage (V)	CU331SP Output Max Current (I)	Drive KVA Rating	Factor x 2.5	Minimum Generator Size (Rounded) (W}	Minimum Generator Size (kW}
2	200-240	264	10.6	2798	x 2.5	7000	7.0
3			12.5	3300		8500	8.5
5			24.2	6389		1600	16.0

Table 42

CUE and CU331SP Wire Sizing

Cable Type	Maximum Cable Length
Screen motor cable	500 Ft. (152 m)
Unscreened motor cable	1000 Ft. (305 m)
Signal cable	1000 Ft. (305 m)

Table 43

Fuses and Conductors				
HP	Max Fuse Size Amps	Fuse Type	Max Conductor (AWG)	Max Conductor (mm^2)
2	40	gG	7	10
3	40	gG	7	10
5	80	gG	7	10

UL Fuses and Conductors			
HP	Max Fuse Size Amps	Bussman RK1	Max Conductor (AWG)
2	40	KTN-R40	7
3	40	KTN-R40	7
5	80	KTN-R80	7

Table 44

Grundfos CUE (Variable Frequency Drive (VFD):

A comprehensive series of wall mounted frequency converters with E-Pump functionality and user interface

Main Applications:

Industry, Building services, Municipal Water Supply and Irrigation application.

Features:
Comprehensive range .75Hp – 300 Hp

Five different power supplies – 1 Phase, 200-240 V, 50/60 HZ (1.5 – 7.5 Hp)

CUE Control

Control Modes :

Constant Pressure With/Without stop function
Constant Differential Pressure
Proportional Pressure
Constant Level With/Without stop function
Constant Temperature
Dry Run Protection
Duty/Standby
Mechanical Bearing Supervision Smart Interface Multiple Input / Output options Multiple Network connection options

Motor (Hp)	Phase (PH)	CUE Rated Input Voltage (V)	CUE Max Input Voltage (V)	CUE Max Output Current (A)	Drive KVA Rating	x 2.5	Minimum Generator Size (Rounded) (W}	Minimum Generator Size (kW}
7-1/2	1	200-240	264	30.8	8131	x 2.5	20400	20.4
7-1/2	3	200-240	264	30.8	8131	x 2.5	20400	20.4
10	3	200-240	264	46.2	12197	x 2.5	30500	30.5
15	3	200-240	264	59.4	15682	x 2.5	39200	39.2
20	3	200-240	264	74.8	19747	x 2.5	49400	49.4
25	3	200-240	264	88.0	23232	x 2.5	58100	58.1
30	3	200-240	264	115.0	30360	x 2.5	75900	75.9
7-1/2	3	380-500	550	14.5	7975	x 2.5	20000	20.0
10	3	380-500	550	21.0	11550	x 2.5	28900	28.9
15	3	380-500	550	27.0	14850	x 2.5	37200	37.2
20	3	380-500	550	34.0	18700	x 2.5	46800	46.8
30	3	380-500	550	40.0	22000	x 2.5	55000	55.0
40	3	380-500	550	52.0	28600	x 2.5	71500	71.5
50	3	380-500	550	65.0	35750	x 2.5	89400	89.4
60	3	380-500	550	80.0	44000	x 2.5	110000	110.0
75	3	380-500	550	105.0	57750	x 2.5	144400	144.4
100	3	380-500	550	130.0	71500	x 2.5	178800	178.8
125	3	380-500	550	160.0	88000	x 2.5	220000	220.0
150	3	380-500	550	190.0	104500	x 2.5	261300	261.3
200	3	380-500	550	240.0	132000	x 2.5	330000	330.0
250	3	380-500	550	302.0	166100	x 2.5	415300	415.3

Table 45

Note - For proper selection of fuses and maximum wire sizing, review the CUE Installation and Operating Manual starting on **page 41**.

SQE with CU301, Submersible Motors with CUE or CU331SP

Diaphragm tank

The stop function requires a diaphragm tank of a certain minimum size. The tank must be installed as close as possible after the pump and the precharge pressure must be 0.7 x actual shut off pressure set point.

See pressure tank manufacture for more specifications, installation and service recommendations.

Constant Pressure Systems - Pressure Tank Sizing

CU331SP and CUE Pressure Tank Sizing

The stop function requires a diaphragm tank of a certain minimum size. The tank must be installed as close as possible after the pump and the precharge pressure must be 0.7 x actual setpoint. Recommended diaphragm tank size:

Rated Flow Of Pump GPM (m^3/h)	Minimum Diaphragm Tank Size Gallons (Liters)
0-26 (0-6)	2 (8)
27-105 (7-24)	4.4 (18)
106-176 (25-40)	14 (50)
177-308 (41-70)	34 (120)
309-440 (71-100)	62 (180)

Table 46

Note - If the diaphram tank sized above is installed in the system, the factory setting of ΔH is the correct setting. If the tank installed is too small, the pump will start and stop too often. This can be remedied by in creasing ΔH.

Fixed Speed Standard Systems

- SQ and SP on a submersible motor with pressure switch, requires minimum 1 minute pump run time.
- See pressure tank manufacturer proper sizing of tank capacity/draw down.

Pressure Tanks serve several functions in pressure controlled water systems.

Required:
Contain a cushion of air at properly set psi to work with the pressure switch or controller to turn the pump on and off efficiently. Without the cushion of air in the tank, the system/pump will rapid cycle on and off shorting the life of the motor and consume large amounts of electrical power.

Draw Down is the amount of gallons stored in the pressure tank and used between pump cycles. The general rule is to size the tank to the GPM of the pump so that once the pump turns on, it will run one minute to fill the tank before shut off. This proper sizing keeps the pump from over cycling, shortening the life of the motor and reducing the amount of electrical power consumption. Two or three pressure tanks can be installed in a system to add up to the recommended size tank capacity.

Benefits:
Pressure tanks will absorb water hammer so not to damage the system components and help to reduce water hammer noise. Fewer start stop cycles extend motor life and reduce electrical power cost.

Before starting any work on the CU 301, make sure that the electricity supply has been switched off and that it cannot be accidentally switched on.

The CU 301 continuously receives operating data from the pump. In case of an alarm, the service indicator light is permanently on, **see Fig. 54**.

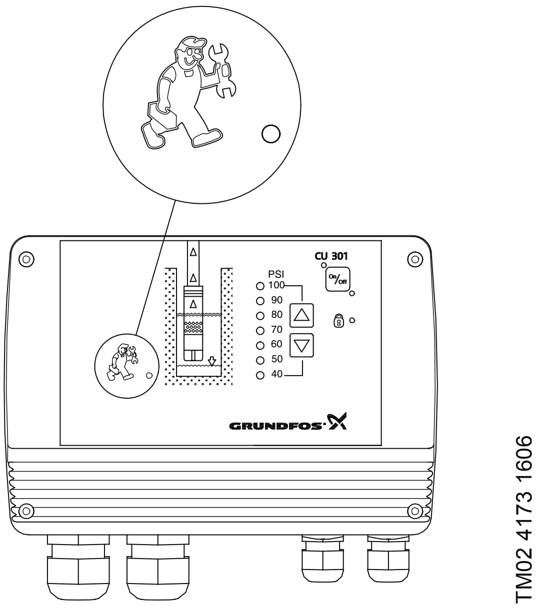


Fig. 54

The service indicator light will be permanently on if one of the following alarm situations occurs:

- Sensor defective
- Overload
- Overtemperature
- Speed reduction
- Voltage alarm
- No contact to pump

To identify the cause of the service alarm, it is necessary to remove the front cover from the CU 301 or use the R100 or Grundfos GO. Fit the front cover as shown in **Fig. 55** to avoid disconnecting the multi-core cable.

A number of LEDs are mounted on the supply board inside the CU 301, see CU 301 owners manual, section 4. Position of LEDs.

LEDs and alarm texts on the supply board

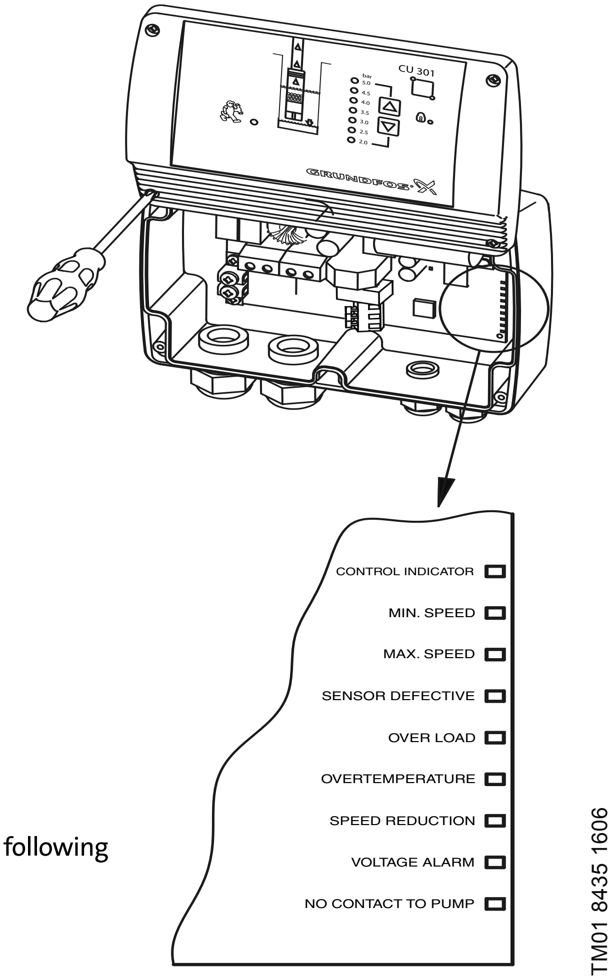


Fig. 55

Electronically controlled systems, at times, encounter problems. Grundfos CU301 controllers are equipped with diagnostic features to aid in troubleshooting the application as well as the electronics. Each controller has a series of Fault/Warning lights or codes that provide the troubleshooter with key indicators of the system condition. Refer to the Installation and Operating Manuals for additional information.

SQE/CU301 Fault Indicators

Alarm Indication	Description
No Fault Indication	No alarms are register by the CU 301
No Contact to Pump	No communication between the CU 301 and the pump.
Overvoltage	The supply voltage exceeds the limit value.
Under Voltage	The supply voltage us below the limit value.
Dry Running	The dry-running protection of the pump has been activated.
Over Temperature	the temperature of the motor exceeds the limit value.
Overload	The current consumption of the motor exceeds the limit value.
Sensor Defective	The sensor signal has fallen outside the measuring range set. The sensor signal of a 4 -20mA or 2-10V sensor is below 2 mA or 1V respectively.

Table 47

Fault	Possible cause	Remedy
1. No light in the front cover.	a) The ribbon cable connection is loose or defective.	• Check that the ribbon cable connection is secure. • Is the control indicator LED flashing? If not, the CU 301 is defective.
2. The pump does not start. The green indicator light in the On/Off button is on. No alarm is indicated.	a) The CU 301, the pressure sensor or the pump is defective.	Check • That the control indicator LED is flashing. If not, the CU 301 is defective. • That the system pressure is 7 psi below the pressure setting. If so, the pump is supposed to start. Open a tap to be sure. If the pump starts, the system is probably OK. The system pressure can be read on the pressure gauge. • Refer to fault 13 to troubleshoot the pressure sensor. If the pump has not started yet, proceed as follows: • Press the On/Off button for 5 seconds. If the pump starts, the CU 301 or the sensor may be defective. **Note: The pressure is not controlled and may rise to a high level. Press the on/off button to off.**
3. The pressure is not constant.	a) The pump is not of the correct type or the precharge pressure of the diaphragm tank is incorrect.	Check • That the LED for Max. speed or Min. speed is on. If so, this indicates that the pump has reached a limit. See CU 301 owners manual, section *1.3 System sizing*. Replace the pump, if necessary. • The precharge pressure of the diaphragm tank. **Note: Remember to stop and drain the system before the tank precharge pressure is checked.** • To make sure the diaphragm tank is the 2 gal. size. • Whether the sensor is positioned far away from the tap. If so, the pressure variations may be caused by friction losses, see CU 301 owners manual, section *1.5 Positioning the pressure sensor*.
	b) No contact between SQE pump and CU 301 control unit.	Check that the LED for "No contact to pump" is on. If so, go to fault no. 14.
4. The pump is running continuously.	a) The pump cannot deliver the set pressure. The CU 301 or the sensor is defective.	• Try to lower the pressure setting, see CU 301 owners manual,section *1.3 System sizing*. Note that the pump may run for about 15 to 20 seconds before it stops. • Check that the control indicator LED is flashing. • Check that the pipe end of the sensor is not blocked. If so, remove the blockage. • Try to stop the pump by means of the On/Off button. If this is not possible, the CU 301 is defective. Replace the CU 301. • Refer to fault 13 to troubleshoot the pressure sensor.

(continued on the following page)

5. The CU 301 indicates "No contact to pump".	a) The motor is not an MSE 3.	If the pump has already worked satisfactorily with a CU 301 or a CU 300, the motor can be expected to be an MSE 3. There is no technical way of determining the motor type. The only way is to read the nameplate engraved in the motor sleeve.
	b) The pump cable is longer than 650 feet.	Reduce the length of the pump cable.
	c) Cable breakage.	Switch off the main power supply to the CU 301. Connect motor leads directly to the main power supply. Switch on the main power supply again. The pump is now connected direct to the main power supply without interfer-ence from the CU 301. Does the motor start? **Yes:** The cable is OK. Go to point d). **No:** Switch off the main power supply again. Remove cable and cable plug from the motor and ohm out cable in-cluding plug. Is the cable OK? **Yes:** The motor is defective. **No:** Replace the cable.
	d) Cross communication with adjacent CU 301.	If another CU 301 is installed: • Insure each unit has a unique number assigned. See CU 301 owners manual, section *5.3.10 Number*. • If pump cables run parallel to each other, physically separate them by 12-14 inches or rewire using shielded cable.
	e) The CU 301 communication part is defective.	Are the three CU 301 supply board LEDs in pos. 2, 3 and 4 on and is the control indicator LED flashing? See CU 301 owners manual, section *4. Position of LEDs*. **Yes:** • The main power supply is OK. • Assign the system a new number. If this does not work, the CU 301 or the motor communication part is defective. Replace the CU 301 and give the new system a number between 1 and 64 in order to obtain correspondence between the numbering of the SQE pump and the CU 301. **Note:** Two systems on the same main power supply must not have the same number! Is the LED "No contact to pump" of the new CU 301 also on? **Yes:** The CU 301 is OK. Go to point f). **No:** The CU 301 which was removed is defective.
	f) The MSE 3 motor communication part is defective.	As a consequence of the above-mentioned checks, replace the MSE 3 motor.
6. Even AFTER replacement, the CU 301 indicates "No contact to pump".	a) Numbering of SQE pump and CU 301 is different.	If an SQE/CU 301 system has been given a number, this number is stored in both the SQE and CU 301. A new CU 301 or SQE may not have a number corresponding to the number stored in the previous unit. Therefore, "No contact to pump" is indicated even if there is no fault. Give a new system the number between 1 and 64 in order to obtain correspondence between the numbering of the SQE pump and the CU 301. **Note:** Two systems on the same main power supply must not have the same number!

(continued on the following page)

7. The CU 301 indicates "Overvoltage" or "Undervoltage".	a) The supply voltage is unstable or outside the voltage range specified for the installed motor type.	Check - possibly over a period of time - that the supply voltage is according to the values below. • Motor type 0.5 hp = 198-315 V • Motor type 0.75 hp = 198-315 V • Motor type 1.0 hp = 207-315 V • Motor type 1.5 hp = 207-315 V. Voltage range for 100-115 V motors: • Motor type 0.5 hp = 90-180 V. **Note:** As the voltage is detected at the motor, allow for the voltage drop in the pump cable.
8. The CU 301 indicates "Dry running".	If the power consumption is lower than the dry-running stop setting and the motor speed is within 1,000 rpm of programmed maximum speed, for an accumulated period of 5 seconds, the pump will be stopped.	
	a) The pump performance is too high for the well yield.	Replace the pump with a smaller pump or reduce the pump performance, by lowering maximum speed, or reducing set pressure.
	b) The well screen is blocked.	Check the well capacity and restore water supply to the well.
	c) The dry-running stop setting is incorrect.	Check and correct the setting, see CU 301 owners manual, section *5.3.5 Dry-running stop*.
9. The CU 301 indicates "Speed reduction" and "Undervoltage".	Speed reduction is activated so as to maintain a reduced performance. When the supply voltage falls so low that it can no longer supply the necessary current to maintain 3,000 RPM, the pump will be stopped.	
	a) The supply voltage is unstable or lower than the voltage range specified for the installed motor type.	Restore correct supply voltage.
	b) The pump is not of the correct type.	Install correct pump type.
	c) The voltage drop in the pump cable is too great.	Replace the pump cable with lower gauge wires.
10. The CU 301 indicates "Speed reduction" and "Overload".	Speed reduction is activated so as to maintain a reduced performance.	
	a) The pump is worn or blocked.	The pump must be serviced.
	b) The pump is too large	Replace pump with proper size pump.
11. The CU 301 indicates "Overtemperature".	The temperature sensor in the motor is sensing a temperature above the values stated in *8. Technical data*, factory settings.	
	a) Insufficient cooling of the motor.	Restore correct cooling of the motor. The flow velocity past the motor should be at least 0.5 ft/s.
12. The CU 301 indicates "Overload".	a) The pump is worn or blocked.	The pump must be serviced.
	b) The pump is too large	Replace pump with proper size pump.

(continued on the following page)

13. The CU 301 indicates "Sensor defective".	a) The pressure sensor is defective.	Check that the sensor is wired correctly. Check that the R100 or GO Remote setting of the sensor is correct, see CU 301 owners manual, section *5.3.1*. If the sensor type is 4-20 mA, measure the DC voltage across the sensor input terminals. If the DC voltage measured at the sensor input terminals is not between 2 and 10 V the sensor or wiring is defective. Refer to CU 301 owners manual, section *9.*, page 28, for additional troubleshooting assistance. Replace defective parts. Are the LED "Sensor defective" and the LED, pos. 1, on? See CU 301 owners manual,section *4. Position of LEDs*. **Yes:** The total load of 24 VDC from terminal 5 is above 100 mA. Disconnect the sensor in order to determine if it is defective. Replace defective sensor. **No:** The load is OK, but the CU 301 sensor input may be defective.
14. The pump is operating on/off.	a) No communication.	Check that the LED "No contact to pump" is on. If so, the control unit CU 301 starts and stops the pump, based on the sensor signal only. The CU 301 has to be reset every 250 stops. Refer to fault no. 5 for remedy.
15. Excess pressure, for a short moment, at start of consumption.	a) Cut-in speed is too high.	Reduce the cut-in speed, see CU 301 owners manual, section *5.3.7 Cut-in speed*.

SP Pumps with CU 331SP / CUE Variable Frequency Drive (VFD)

Indicator lights				
Off Orange	**On Green**	**Alarm Red**	**Condition/cause**	**Remedy**
Off	**Off**	**Off**	**The display of the CUE is off**	
			1. Fault in the power supply of the control panel.	Check the supply voltage to the CUE.
			2. The control circuit power supply is overloaded.	Pull all signal terminals out of the control board. • If the control panel lights up: The fault is in the control circuit. Check the control circuit for short-circuits or faulty connections before reconnecting the signal terminals. • If the control panel does not light up: Contact Grundfos Service.
On	**Off**	**Off**	**The CUE has been switched off with the on/off button**	
			1. The CUE has been switched off with the on/off button.	Switch on the CUE with the on/off button. •
On	**Off**	**On**	**The CUE has been switched off with the on/off button and is in alarm state.**	
			1. There is an alarm indication in the display of the CUE.	¿÷ Alarm cause and remedy, see CUE Service • nstructions, section 2.5 Fault finding by means of alarm and warning codes. ¾÷ Reset the alarm. (If it is a locked alarm, the • nains supply must be switched off before the CUE can be restarted.) ½÷ witch on the CUE again with the on/off button.
Off	**Off**	**On**	**The CUE has stopped due to an alarm**	
			1. An alarm has caused the CUE to stop.	means of alarm and warning codes÷Service • structions, section 2.5 Fault finding by means of alarm and warning codes. ÷¾Reset the alarm. (If it is a locked alarm, the mains supply must be switched off before the CUE can be restarted.)
Off	**On**	**Off**	**The CUE is in operation, i.e. the pump connected is running or has been stopped by a stop function (no alarm)**	
			1. Stopped by stop function.	• No: Check the settings of the stop function. • Yes: Normal operational stop. The CUE will restart when the stop function has ceased.
			2. External setpoint has been activated.	a) If the markers for actual setpoint and actual value in display 1.1, Setpoint, are level, the pump has been stopped according to its settings. b) If external setpoint = 0 % in display 1.2, Operating mode, the CUE will not detect an input signal. Check the voltage on terminal 53. • If no voltage is measured, the fault is in the external control circuit. • If the voltage measured is greater than 0 V, the CUE is defective. Contact Grundfos Service. c) If external setpoint > 0 % in display 1.2, Operating mode: Check the voltage on terminal 53: If the measured voltage does not correspond to the external setpoint in display 1.2, the CUE is defective; contact Grundfos Service.

Indicator lights			Condition/cause	Remedy
Off Orange	**On Green**	**Alarm Red**		
Off	**Flashing**	**Off**	**The CUE is ready for operation, but has been stopped by the user, an external start/stop signal or via the bus**	
			1. The CUE has been stopped in display 1.2, Operating mode.	Restart the CUE by selecting another operating mode: *Min.*, *Max.* or *Normal*.
			2. The CUE has been stopped by an external start/stop signal, or there is a fault in the external control circuit.	Check that the CUE receives a start signal on the external start/stop input. (Terminals 18 and 20 must be connected).
			3. The CUE has been stopped by a signal on digital input DI 2, 3 or 4.	Check whether the inputs have been set to Ext. fault, Flow contact or Dry running (displays 3.9 to 3.11).
			4. The CUE has been stopped via the bus.	Check display 2.2, Operating mode. If the operating mode is "Stop", and is from "Bus", the CUE has detected a stop signal via the "Bus". Contact the system integrator or Grundfos Service if the bus does not send a stop signal.
Off	**On**	**On**	**The CUE in operation, but there is an unreset warning/alarm**	
			1. There is or has been an alarm or a warning that did not cause a stop.	See the alarm text in the display.
Off	**Flashing**	**On**	**The CUE is ready for operation, but has been stopped by the user, an external start/stop signal or via the bus, and there is an unreset warning/alarm**	
			1. The CUE has been stopped in display 1.2, Operating mode.	Restart the CUE by selecting another operating mode: *Min.*, *Max.* or *Normal*.
			2. The CUE has been stopped by an external start/stop signal, or there is a fault in the external control circuit.	Check that the CUE receives a start signal on the external start/stop input. (Terminals 18 and 20 must be connected).
			3. The CUE has been stopped by a signal on digital input DI 2, 3 or 4.	Check whether the inputs have been set to Ext. fault, Flow contact or Dry running (displays 3.9 to 3.11).
			4. The CUE has been stopped via the bus.	Check display 2.2, Operating mode. If the operating mode is "Stop", and is from "Bus", the CUE has detected a stop signal via the "Bus". Contact the system integrator or Grundfos Service if the bus does not send a stop signal.
			5. There is or has been an alarm or a warning that did not cause a stop.	See the alarm text in the display.

2.5.1 Alarm and warning list

The following list gives you an overview of the possible alarms and warnings and a description of the causes and suggestions for remedy.

These abbreviations are used in the column "Alarm":

W: Warning.

A: Alarm.

L: Locked alarm: The alarm cannot be reset until the main power supply has been switched off.

1): The action in case of alarm depends on the pump type.

Alarm code	Fault indication	Alarm	Alarm action	Reset
Cause/explanation	**Remedy**			
1/14	Too high leakage current	W L	Stop	Man.
There is a discharge or current unbalance: • between the CUE output phases or from phases to earth • in the cable to the motor • in the motor • There may be a great unbalance between the motor winding resistances. • The CUE is faulty.	Switch off the CUE, and remove the motor cable from terminals 96, 97 and 98. a) Meg these parts: • the cable between the CUE and the motor • the motor. b) Contact Grundfos Service.			
2/4	Phase failure (only three-phase CUE)	A	Stop	Aut.
Missing phase, or the supply voltage unbalance is too high.	Re-establish the voltage supply to the CUE according to the nameplate. If the fuses blow again, or if the alarm cannot be reset, contact Grundfos Service.			
3/2004	External fault	A	Stop	Man.
One of the digital inputs • DI 2 (see display 3.9) • DI 3 (see display 3.10) • DI 4 (see display 3.11) is set to "External fault", and the input has been or is still closed.	Check if the digital input set to "External fault" is open or closed. • If the input is closed, reset the alarm cause in the external control circuit.			
16/1	Other fault	W	-	Aut.
Overload of the 10 V voltage supply to the external control circuit. The voltage between terminals 50 and 39 is less than 10 V.	Pull the terminal block for the external input signals out of the CUE. • If the warning disappears, the fault is overload in the control circuit for the external setpoint. • If the warning does not disappear, contact Grundfos Service.			
16/-	Other fault	W A	-	Aut./man.
Other alarms with an alarm code starting at 16/.	Contact Grundfos Service.			
30/2005	Replace motor bearings	W	-	Man.
The pump has reached the factory-set number of operating hours, and the bearings have been relubricated the maximum number of times.	Replace the bearings, and confirm the replacement in display 3.20, Motor bearings.			
32/5	Overvoltage	W	-	Aut.
The supply voltage has caused the intermediate circuit voltage (DC) to be higher than the warning limit of the control system. The CUE is still active.	• Check the supply voltage according to the CUE nameplate. • Check the mains supply. (See also 32/7.) • If the main power supply is okay, contact Grundfos Service.			

Alarm/warning limits:			
Voltage supply:	3 x 200-240 V	3 x 380-480 V	3 x 525-600 V
Voltage warning high:	390 VDC	810 VDC	943 VDC

Alarm code	Fault indication	Alarm	Alarm action	Reset
Cause/explanation	**Remedy**			
32/7	Overvoltage	A	Stop	Aut.
The supply voltage has caused the intermediate circuit voltage (DC) to be higher than the alarm limit of the control system. The CUE will stop after a while.	• Check the supply voltage according to the CUE nameplate. • Check the main power supply. (See also 32/5.) • If the main power supply is okay, contact Grundfos Service.			
	Alarm/warning limits:			
	Voltage supply:	3 x 200-240 V	3 x 380-480 V	3 x 525-600 V
	Overvoltage:	410 VDC	855 VDC	975 VDC
40/6	Undervoltage	W	-	Aut.
The intermediate circuit voltage (DC) is lower than the warning limit of the control system. The CUE is still active.	• Increase the supply voltage to the prescribed level according to the CUE nameplate. • Check the main power supply. (See also 40/8.) • If the main power supply is okay, contact Grundfos Service.			
	Alarm/warning limits:			
	Voltage supply:	3 x 200-240 V	3 x 380-480 V	3 x 525-600 V
	Voltage warning low:	205 VDC	410 VDC	585 VDC
40/8	Undervoltage	W A	Stop	Aut.
The intermediate circuit voltage (DC) is lower than the alarm limit of the control system.	• Increase the supply voltage to the prescribed level according to the CUE nameplate. • Check the main power supply. (See also 40/6.) • If the main power supply is okay, contact Grundfos Service.			
	Alarm/warning limits:			
	Voltage supply:	3 x 200-240 V	3 x 380-480 V	3 x 525-600 V
	Undervoltage:	185 VDC	373 VDC	532 VDC
48/9	Overload	W A	Stop	Aut.
The CUE is stopping due to an overload. (The current is more than 10 % higher than the maximum output current stated on the nameplate.) First a warning is given, which is followed by an alarm if the overload exists for more than 1 minute.	• Check the motor current according to the CUE nameplate. • Check the pump.			
48/10	Overload	A	Stop	Aut.
The electronic thermal protection of the CUE has detected that the motor is persistently overloaded.	• Check the motor current according to the CUE nameplate. • Check the pump. • Go through the start-up guide.			
48/16	Overload	L	Stop	Man.
There is a short-circuit in the motor cable, filter or motor.	Switch off the CUE, and remove the motor cable from terminals 96, 97 and 98, or high-voltage test the cable, filter and motor.			
49/13	Overload	W A	Stop	Aut.
The CUE is stopping due to an overload. (The current is more than 10 % higher than the maximum output current stated on the nameplate.) First a warning is given, which is followed by an alarm if the overload exists for more than 1 minute.	Switch off the CUE, and check that the motor shaft can be turned and that the motor size fits the CUE.			
55/12	Overload	W	Stop	Aut.
Torque limitation. The CUE is overloaded and limits the power to the motor. The pump may therefore not reach full speed.	• Check the motor current according to the CUE nameplate. • Check the pump. • Go through the start-up guide, as some settings may be incorrect.			
55/59	Overload	W	-	Aut.
The CUE is overloaded, but the alarm limit has not yet been reached.	• Check the motor current according to the CUE nameplate. • Check the pump. • Go through the start-up guide, as the current is higher than the value in display 6/16 of the start-up guide.			

Alarm code	Fault indication	Alarm	Alarm action	Reset
Cause/explanation	**Remedy**			
57/93	Dry running	A	Stop	Aut.
One of the digital inputs • DI 2 (see display 3.9) • DI 3 (see display 3.10) • DI 4 (see display 3.11) is set to "Dry running", and the input has been or is still closed.	Check if the digital input set to "Dry running" is open or closed. • If the input is closed, reset the signal on the external dry-running sensor. • If the input is open, contact Grundfos Service.			
64/-	Too high CUE temperature	W A	Stop	Aut.
The internal temperature of the CUE is too high. Fault causes: • The ambient temperature is higher than 45 °C (113 °F). Lower the ambient temperature, for instance by providing forced cooling.				
• The installation was not carried out according to the CUE installation and operating instructions.	Check the installation of the CUE.			
• The fan is dirty or defective.	Clean the fan, or contact Grundfos Service.			
77/2009	Duty/standby communication error	W	-	Aut.
Communication between the two pumps set to duty/standby function has been interrupted.				
• The pumps are not set correctly.	Check the setting according to the CUE installation and operating instructions.			
• The voltage supply to the standby pump has been interrupted.	Re-establish the voltage supply.			
• The communication cable has been disconnected.	Check the communication cable.			
89/2011	Sensor 1 outside range	A	1)	Aut.
Sensor 1 (terminal 54): The analog input signal has fallen below these control values for more than 500 ms: Millisecond (ms) Type: 4-20 mA: Alarm under 2 mA (reset over 3 mA). Type: 2-10 V: Alarm under 1 V (reset over 1.5 V). The types 0-20 mA and 0-10 V are not monitored.				
Fault at start-up:				
1. No sensor is connected.	Connect a sensor according to section 6.3 of the CUE installation and operating instructions.			
2. Contact A54 for selection of signal type is set incorrectly.	Set the contact correctly according to section 6.3.5 of the CUE installation and operating instructions.			
3. Display 3.15 is set incorrectly for the sensor.	Correct the sensor setting.			
4. The sensor has been connected incorrectly.	Connect the sensor correctly according to section 6.3 of the CUE installation and operating instructions.			
Fault after start-up:				
5. Incorrect voltage supply to sensor.	Check that there are 24 ± 1 VDC between terminals 12 and 55: • If the voltage is not okay, contact Grundfos Service. • If the voltage is okay, check if there is minimum 4 mA or 1 V between terminals 54 and 55. If yes, contact Grundfos Service.			
6. Sensor or sensor cable defective.	If the cable is missing, or the sensor is defective, contact Grundfos Service.			

Alarm code	Fault indication	Alarm	Alarm action	Reset
Cause/explanation	**Remedy**			
91/2013	Temperature sensor 1 outside range	1)	1)	Aut.
The temperature sensor connected to terminal 5 in the MCB 114 sensor input module measures a value under –50 °C (-58 °F) or over 200 °C (392 °F).				
1. The sensor has been connected incorrectly.	Check the connection according to section 6.5 of the CUE installation and operating instructions.			
2. The supply to the sensor is incorrect.	Check that there are 24 VDC between terminals 4 and 6 of the MCB 114. • If the voltage is not okay, contact Grundfos Service. • If the voltage is okay, check the sensor resistance as described below.			
3. The sensor is defective.	Measure the sensor resistance using an ohmmeter: • Type Pt100: If the resistance is less than 80 Ohm (corresponding to –50 °C or -58 °F) or greater than 240 Ohm (corresponding to 200 °C or 392 °F), the sensor is defective and must be replaced. At 20 °C, the resistance must be 107 Ohm. • Type Pt1000: If the resistance is less than 800 Ohm (corresponding to –50 °C or -58 °F) or greater than 1773 Ohm (corresponding to 200 °C or 392 °F), the sensor is defective and must be replaced. At 20 °C (68 °F), the resistance must be 1077 Ohm. If the sensor is not defective, contact Grundfos Service.			
93/2012	Sensor 2 outside range	1)	-	Aut.
Sensor input 2 (terminal 2 of MCB 114) is or has been under the control value: Type: 4-20 mA: Alarm under 2 mA (reset over 3 mA).				
Fault at start-up:				
1. The CUE menu setting does not match the sensor type installed.	Check the setting in display 3.16, Sensor 2.			
2. The sensor has been connected incorrectly.	Check the connection according to section 6.5.2 of the CUE installation and operating instructions.			
Fault after start-up:				
3. Incorrect voltage supply to sensor.	Check that there are 24 VDC between terminals 1 and 3 of the MCB 114: • If the voltage is not okay, contact Grundfos Service. • If the voltage is okay, check if there is minimum 4 mA between terminals 2 and 3. If yes, contact Grundfos Service.			
4. Sensor or sensor cable defective.	If the cable is missing, or the sensor is defective, contact Grundfos Service.			

Alarm code	Fault indication	Alarm	Alarm action	Reset
Cause/explanation	**Remedy**			
96/2010	Setpoint signal outside range	A	1)	Aut.
External setpoint (terminal 53): The external setpoint has fallen below these control values for more than 500 ms: Type: 4-20 mA: Alarm under 2 mA (reset over 3 mA). Type: 2-10 V: Alarm below 1 V (reset over 1.5 V). The types 0-20 mA and 0-10 V are not monitored.				
Fault at start-up:				
1. Contact A53 for selection of signal type is set incorrectly.	Set the contact correctly according to section 6.3.5 of the CUE installation and operating instructions.			
2. Display 3.3, Ext. setpoint, is set incorrectly for the signal in question.	Check the setting in display 3.3, Ext. setpoint.			
3. The external setpoint signal is connected incorrectly.	Connect the signal correctly according to section 6.3 of the CUE installation and operating instructions.			
Fault after start-up:				
4. Incorrect voltage supply to the external setpoint signal.	Check that there are 10 VDC between terminals 50 and 55: • If the voltage is not okay, contact Grundfos Service. • If the voltage is okay, check if there is minimum 4 mA or 1 V between terminals 53 and 55. If yes, contact Grundfos Service.			
5. Signal transmitter or signal cable defective.	If the cable is missing, or the signal transmitter is defective, contact Grundfos Service.			
148/2007 **149/2008**	Too high bearing temperature	W A	- Stop	Aut. Aut.
148/2007: The D-end motor bearing is too hot. 149/2008: The ND-end motor bearing is too hot.				
1. Motor cooling is not optimum.				
- The motor is dirty.	Clean the motor.			
- The fan is defective.	Replace the fan.			
- The bearing is not lubricated correctly.	Check the lubrication of the bearing.			
- The sensor or its cable is defective.	Check the sensor and cable.			
2. The temperature sensor connected to terminal 5 or 8 of the MCB 114 is outside the monitoring range.	a) Check the connection according to section 6.5 of the CUE installation and operating instructions. b) Check that there are 24 VDC between terminals 4 and 6 or 7 and 9 of the MCB 114. - The voltage is not okay, contact Grundfos Service. - The voltage is okay, check the sensor resistance as described below. c) Measure the sensor resistance using an ohmmeter: - Type Pt100: If the resistance is less than 80 Ohm (corresponding to –50 °C or -58 °F) or greater than 240 Ohm (corresponding to 200 °C or 392 °F), the sensor is defective and must be replaced. At 20 °C, the resistance must be 107 Ohm. - Type Pt1000: If the resistance is less than 800 Ohm (corresponding to –50 °C or -58 °F) or greater than 1773 Ohm (corresponding to 200 °C or 392 °F), the sensor is defective and must be replaced. At 20 °C (68 °F), the resistance must be 1077 Ohm. If the sensor is not defective, contact Grundfos Service.			
155/33	Inrush fault	A	Stop	Aut.
The maximum number of cut-ins has been exceeded. Permissible number of cut-ins: • CUE enclosure A: 2/minute. • CUE enclosures B and C: 1/minute.				
1. The CUE is started/stopped by connecting/interrupting the mains supply.	Make sure to use a digital input (terminal 18, start/stop) for external control of start/stop.			
2. There is a fault in the main connection of the CUE.	Tighten the supply terminals 91, 92 and 93. (See the correct tightening torque in the CUE installation and operating instructions.)			
3. There is a fault in the CUE.	Contact Grundfos Service.			

Alarm code	Fault indication	Alarm	Alarm action	Reset
Cause/explanation	**Remedy**			
175/2014	Temperature sensor 2 outside range	A	1)	Aut.
The temperature sensor connected to terminal 8 in the MCB 114 sensor input module measures a value under –50 °C (-58 °F) or over 200 °C (392 °F).				
1. The sensor has been connected incorrectly.	Check the connection according to section 6.5 of the CUE installation and operating instructions.			
2. The supply to the sensor is incorrect.	Check that there are 24 VDC between terminals 7 and 9 of the MCB 114. • If the voltage is not okay, contact Grundfos Service. • If the voltage is okay, check the sensor resistance as described below.			
3. The sensor is defective.	Measure the sensor resistance using an ohmmeter: • Type Pt100: If the resistance is less than 80 Ohm (corresponding to –50 °C or -58 °F) or greater than 240 Ohm (corresponding to 200 °C or 392 °F), the sensor is defective and must be replaced. At 20 °C (68 °F), the resistance must be 107 Ohm. • Type Pt1000: If the resistance is less than 800 Ohm (corresponding to –50 °C or -58 °F) or greater than 1773 Ohm (corresponding to 200 °C or 392 °F), the sensor is defective and must be replaced. At 20 °C (68 °F), the resistance must be 1077 Ohm. If the sensor is not defective, contact Grundfos Service.			
240/2006	Relubricate the motor bearings	W	-	Man.
The motor has reached the factory-set number of operating hours for relubrication of motor bearings.	Lubricate the motor bearings, and confirm the lubrication in display 3.20, Motor bearings.			
241/3	Motor phase failure	W	-	Aut.
No motor is connected to the output of the CUE.	Connect a motor to the CUE.			
241/30	Motor phase failure	A	Stop	Aut.
Motor cable between CUE terminal U and the motor missing.	Switch off the CUE, and check motor phase U.			
241/31	Motor phase failure	A	Stop	Aut.
Motor cable between CUE terminal V and the motor missing.	Switch off the CUE, and check motor phase V.			
241/32	Motor phase failure	A	Stop	Aut.
Motor cable between CUE terminal W and the motor missing.	Switch off the CUE, and check motor phase W.			
242/-	AMA did not succeed	W	-	Aut.
Fault indications concerning AMA (Automatic Motor Adaptation)	AMA only takes place in the start-up and is only of peripheral importance for optimum operation. Reset the warning, and continue. If this is not possible, contact Grundfos Service.			

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