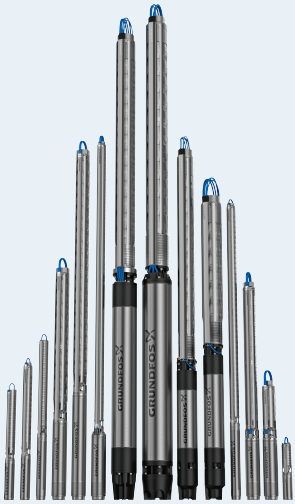
Installation and operating instructions

SP/SPE

SP
Installation and operating instructions
Other languages
http://net.grundfos.com/qr/i/98074911



GRUNDFOS

Original installation and operating instructions

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1. General information

Read this document before you install the product. Installation and operation must comply with local regulations and accepted codes of good practice.

Appliances can be used by persons with reduced physical, sensory, or mental capabilities, as well as persons with a lack of experience and knowledge. This requires that they are given supervision or instruction concerning the use of the appliance in a safe way, and that they understand the hazards involved.

Children shall not play with the appliance. Cleaning and user maintenance shall not be made by children without supervision.

1.1 Hazard statements

The symbols and hazard statements below may appear in Grundfos installation and operating instructions, safety instructions and service instructions.

DANGER

Indicates a hazardous situation which, if not avoided, will result in death or serious personal injury.

WARNING

Indicates a hazardous situation which, if not avoided, could result in death or serious personal injury.

CAUTION

Indicates a hazardous situation which, if not avoided, could result in minor or moderate personal injury.

The hazard statements are structured in the following way:

SIGNAL WORD

Description of the hazard

Consequence of ignoring the warning

- Action to avoid the hazard.

1.2 Notes

The symbols and notes below may appear in Grundfos installation and operating instructions, safety instructions and service instructions.

Observe these instructions for explosion-proof products.

A blue or grey circle with a white graphical symbol indicates that an action must be taken.

A red or grey circle with a diagonal bar, possibly with a black graphical symbol, indicates that an action must not be taken or must be stopped.

If these instructions are not observed, it may result in malfunction or damage to the equipment.

Tips and advice that make the work easier.

Please ensure that the safety instructions and I&O documentation are prepared on your end before commencing the service work.

2. Introduction

These instructions apply to Grundfos submersible pumps, type SP/SPE and SPA, with submersible motors, types Grundfos MS/MMS.

If the pump is fitted with a motor of another brand than Grundfos MS or MMS, note that the motor data may differ from the data stated in these instructions.

2.1 Intended use

Grundfos SP submersible pumps are intended for a wide range of water supply and liquid transfer applications, such as the supply of fresh water to private homes or waterworks, water supply in horticulture and agriculture, drawdown of groundwater and pressure boosting, and various industrial jobs.

3. Handling and storing the product

3.1 Handling

WARNING
Crushing of feet
Death or serious personal injury



- Stack the pumps with the biggest at the bottom, and do not stack above 1 m.
- Use lifting equipment which is approved for the weight of the product.
- Wear personal protective equipment.

WARNING
Crushing of hands
Death or serious personal injury



- Stack the pumps with the biggest at the bottom, and do not stack above 1 m.
- Use lifting equipment which is approved for the weight of the product.



Store the pump in the package until it is ready for installation.

Handle the pump with care.

Do not expose the pump to mechanical impact, vibrations et cetera.

3.2 Storage

Storage temperature

Pump: -20 to +60 °C.

Motor: -20 to +70 °C.

The motors must be stored in a closed, dry and well-ventilated room.

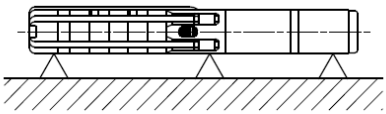


If MMS motors are stored, the shaft must be turned by hand at least once a month. If a motor has been stored for more than one year before installation, the rotating parts of the motor must be dismantled and checked before use.

The pump must not be exposed to direct sunlight.

If the pump has been unpacked, it must be stored horizontally, adequately supported, or vertically to prevent misalignment of the pump. Make sure that the pump cannot roll or fall over.

During storage, the pump can be supported as shown in the figure below.



TM001349

Pump position during storage

Frost protection

If the pump has to be stored after use, it must be stored in a frost-free location, or the motor liquid must be frost-proof.

4. Applications

Grundfos SP submersible pumps are designed for a wide range of water supply and liquid transfer applications, such as the supply of fresh water to private homes or waterworks, water supply in horticulture and agriculture, drawdown of groundwater and pressure boosting, and various industrial jobs.

The pump must be installed so that the suction interconnector is completely submerged in the liquid. The pump can be installed horizontally or vertically. See section *Positional requirements*.

Related information

5.2 Positional requirements

4.1 Pumped liquids

Pumped liquids are clean, thin, non-explosive liquids without solid particles or fibres.

The maximum sand content of the water must not exceed 50/100/150 ppm. A larger sand content will reduce the life of the pump and increase the risk of blockage.

Pump type	Maximum content of sand [ppm]
SP 1A - SP 5A	50
SP 7 - SP 14	150
SP 18 - SP 62	100
SP 77 - SP 215	50

When pumping liquids with a density higher than water (998-1000 kg/m^3), motors with correspondingly higher outputs must be used.

If liquids with a viscosity higher than that of water are to be pumped, contact Grundfos.

N EN 1.4401 and R EN 1.4539 grade stainless steel pump sets are designed for liquids more aggressive than drinking water.

The maximum liquid temperature appears from the section on liquid temperatures and motor cooling.

Related information

5.4 Liquid temperatures and motor cooling

4.2 Sound pressure level

The sound pressure level has been measured in accordance with the rules set out in the EC machinery directive 2006/42/EC.

Sound pressure level of pumps

The values apply to pumps submerged in water.

Pump type	L_{pA} [dB(A)]
SP 1A	less than 70
SP 2A	
SP 3A	
SP 5A	
SP 7	
SP 9	
SP 11	
SP 14	
SP 18	
SP 32	
SP 46/47	
SP 60/62	
SP 77	
SP 95	
SP 125	79
SP 160	79
SP 215	82

Sound pressure level of motors

The sound pressure level of Grundfos MS and MMS motors is lower than 70 dB(A).

Other motor brands: See installation and operating instructions for these motors.

4.3 Drinking water

If the product is used for drinking water, the following precautions must be taken to avoid contamination:

- Before use, make sure that the product does not come into contact with dust or with chemicals not suitable for contact with drinking water, for example lubricants, greases or oils.
- If the pump is used with potentially toxic liquids, it can no longer be used for drinking water.
- Always use original parts to maintain the intended hygienic characteristics of the product.

5. Installation requirements

DANGER
Electric shock
Death or serious personal injury

- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

WARNING
Crushing of feet
Death or serious personal injury

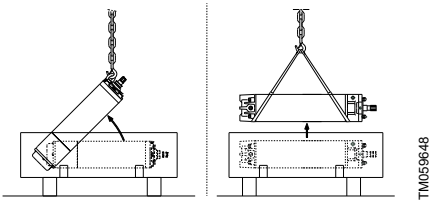
- When lifting the pump out of the box, use lifting equipment that is approved for the weight of the product.
- Wear personal protective equipment.

WARNING
Crushing of hands
Death or serious personal injury

- When lifting the pump out of the box, use lifting equipment that is approved for the weight of the product.
- Wear personal protective equipment.

Unless the requirements in the section on frequency converter operation MS6000P are met, the use of a sine-wave filter is mandatory when operating an SPE pump set.

Grundfos recommends fitting a 30 cm long pipe to the pump to facilitate handling of the pump during installation.



Handling of the motor

5.1 Checking the motor liquid

The motors are factory-filled with a special FDA-approved non-toxic liquid which is frost-proof down to -20 °C.

Check the level of motor liquid and refill if if necessary using tap water.

If frost protection is required, the motor must be refilled with special Grundfos liquid. Otherwise, it can be refilled with tap water, following the procedure described below.

5.1.1 Grundfos MS4000 and MS402 motors

The filling hole for motor liquid is placed in the following positions:

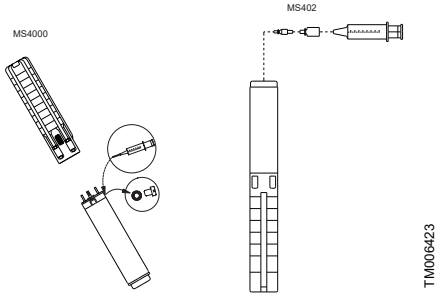
- MS4000: on the side of the motor near the top
- MS402: on the bottom of the motor.

1. Position the submersible pump as shown in the figure below. The filling screw must be at the highest point of the motor.
2. Remove the screw from the filling hole.
3. Inject liquid into the motor with the filling syringe until the liquid begins to overflow from the filling hole. See the figure below.
4. Replace the screw in the filling hole and tighten securely before changing the position of the pump.

Torques

- MS4000: 3.0 Nm.
- MS402: 2.0 Nm.

The submersible pump is now ready for installation.



Motor position during filling - MS4000 and MS402

5.1.2 Grundfos MS6000 motors

- If the motor is delivered from stock, the liquid level must be checked before the motor is installed. See the figure below.
- During service, the liquid level must be checked. See the figure below.

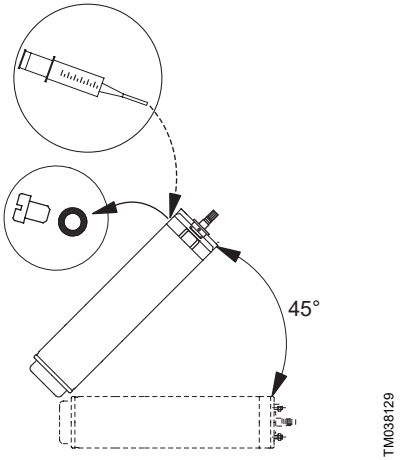
Filling procedure:

The filling hole for motor liquid is placed at the top of the motor.

1. Position the submersible motor as shown in the figure below. The filling screw must be at the highest point of the motor.
2. Remove the screw from the filling hole.
3. Inject liquid into the motor with the filling syringe ntil the liquid begins to overflow from the filling hole.
4. Replace the screw in the filling hole and tighten securely before changing the position of the motor.

Torque: 3.0 Nm.

The submersible motor is now ready for installation.



Motor position during filling - MS6000

5.1.3 Grundfos MMS6, MMS8000, MMS10000 and MMS12000 motors

Filling procedure:

Position the motor at a 45° angle with its top facing upward. See the figure below.

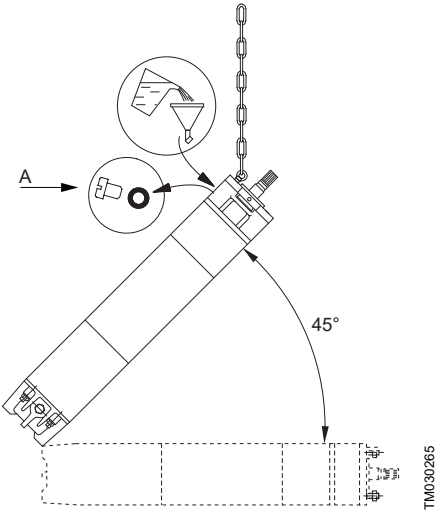
1. Unscrew the plug (A) and place a funnel in the hole.
2. Pour tap water into the motor until the motor liquid inside the motor starts overflowing at the plug (A).

   Do not use motor liquid that contains oil.

3. Remove the funnel and refit the plug (A).

   Before fitting the motor to a pump after a long period of storage, lubricate the shaft seal by adding a few drops of water and turning the shaft.

The submersible motor is now ready for assembly with the pump and ready for installation.



Motor position during filling - MMS

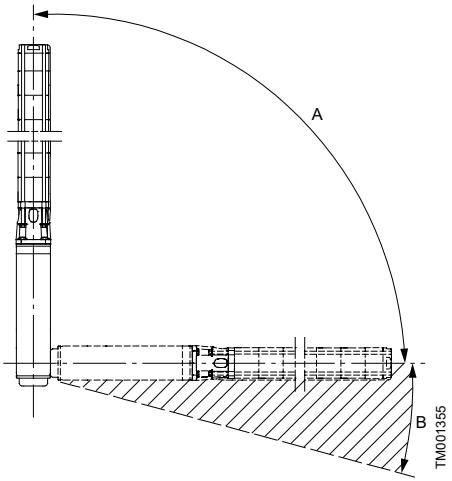
5.2 Positional requirements

WARNING
Crushing of hands
Death or serious personal injury

- If the pump is to be installed in a position where it is accessible, the coupling must be suitably isolated from human touch. The pump can for instance be built into a flow sleeve.

Depending on motor type, the pump can be installed either vertically or horizontally. A complete list of motor types suitable for horizontal installation is shown in the section on Motors suitable for horizontal installation.

If the pump is installed horizontally, the outlet port must never fall below the horizontal plane. See the figure below.



Positional requirements

Pos.	Description
A	Allowed
B	Not allowed

If the pump is installed horizontally, for example in a tank, we recommend that you fit it in a flow sleeve.

Related information

5.2.1 Motors suitable for horizontal installation

5.2.1 Motors suitable for horizontal installation

Motor type	Maximum speed Rated power range (P2) Output power 3000 RPM	Maximum speed Rated power range (P2) Output power 3600 RPM
	[kW]	[kW]
MS	All	All
MMS6	5.5 - 37	5.5 - 37
MMS8000	22-92	22-92
MMS8000P	37-147	37-147
MMS10000	75-170	75-170
MMS12000	147-190	-

CAUTION
Hot surface
Minor or moderate personal injury

- If the pump is used for pumping hot liquids (40 to 60 °C), make sure to prevent contact with the pump and its installation, for example by installing a guard.

During operation, the suction interconnector of the pump must always be completely submerged in the liquid. Make sure that the NPSH values are fulfilled.

5.3 Pump/motor diameter

We recommend that you check the borehole with an inside calliper to ensure unobstructed passage.

5.4 Liquid temperatures and motor cooling

The maximum liquid temperature and the minimum flow velocity past the motor appear from the following table.

Grundfos recommends installing the motor above the well screen in order to achieve proper motor cooling via liquid passing the motor.

In cases where the stated flow velocity cannot be achieved, a flow sleeve must be installed.

If there is a risk of sediment build-up, such as sand, around the motor, a flow sleeve should be used in order to ensure proper cooling of the motor.

Motor type	Temperature version	Power range	Pumped liquid passing the motor	
		[kW]	Max. temperature	Min. flow velocity
MS402	-	All	40 °C	0.15 m/s [1]
MS4000	T40	All	40 °C	0.15 m/s [1]
	T60	All	60 °C Flow sleeve recommended	1.00 m/s [1]
MS6000	T40	All	40 °C	0.15 m/s [1]
	T60	All	60 °C Flow sleeve recommended	1.00 m/s [1]
				0.15 m/s [2]
MS6000 P	T60	All	60 °C	0.15 m/s [1]
MMS6	T50	5.5 - 37	50 °C	0.5 m/s [1]
	T40	45	40 °C	0.5 m/s [1]
MMS8000	T45	22-92	45 °C	0.5 m/s [1]
	T40	110	40 °C	0.5 m/s [1]
MMS8000P	T60	37-147	60 °C	0.5 m/s [1]
MMS10000	T45	75-147	45 °C	0.5 m/s [1]
	T40	170	40 °C	0.5 m/s [1]
	T35	190	35 °C	0.5 m/s [1]
MMS12000	T45	147-190	45 °C	0.5 m/s [1]
	T35	220-250	35 °C	0.5 m/s [1]

1) At an ambient pressure of minimum 1 bar (0.1 MPa)

2) At an ambient pressure of minimum 2 bar (0.2 MPa)

5.4.1 Flow velocity formula

$$V = \frac{Q \times 353}{D^2 - d^2} \quad [m/s]$$

Q	m^3/h	Flow rate
D	mm	Sleeve diameter or borehole diameter
d	mm	Pump diameter

5.5 Pipe connection

If noise may be transmitted to the building through the pipes, we recommend using plastic pipes.

Plastic pipes are recommended for 4" pumps only.

When using plastic pipes, secure the pump by an unloaded straining wire.

WARNING
Hot liquid
Death or serious personal injury



- Use pipes designed for the maximum pump pressure plus 10 % to avoid pipe burst.
- Make sure that the plastic pipes are suitable for the actual liquid temperature.

When connecting plastic pipes, use a compression coupling between the pump and the first pipe section.

6. Electrical connection

DANGER
Electric shock
Death or serious personal injury

- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

DANGER
Electric shock
Death or serious personal injury

- The pump must be earthed.
- The pump must be connected to an external main switch and shall be provided with a means permitting it to be locked in the OFF (isolated) position. Type and requirements as specified in EN 60204-1, 5.3.2.

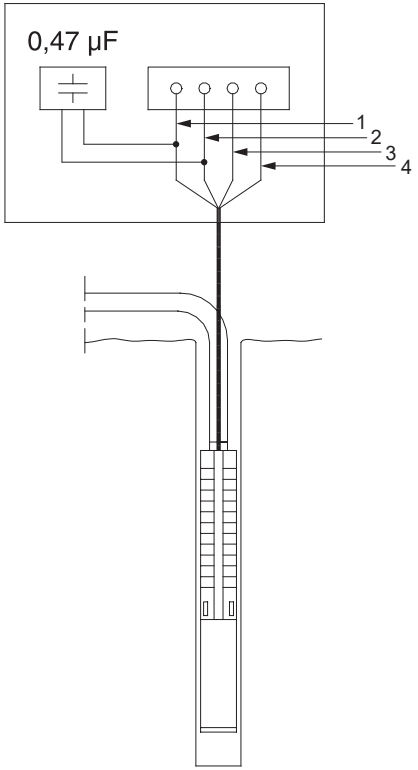
The electrical connection must be carried out by an authorised person in accordance with local regulations.

The supply voltage, rated maximum current, and power factor (cos φ) are specified on a separate nameplate, which must be fitted near the pump installation site.

The required voltage quality for MS and MMS motors, measured at the motor terminals, is -10 % / +6 % of the nominal voltage during continuous operation. This includes variations in supply voltage and cable losses.

Verify that there is voltage symmetry in the power supply lines, meaning that the voltage difference between individual phases is consistent. See Appendix, item 2.

If MS motors with a built-in temperature transmitter (Tempcon) are not installed together with an MP 204 motor protection unit, they must be connected to a 0.47 µF capacitor approved for phase-phase operation (IEC 384-14) to meet the EC EMC directive (2004/108/EC). The capacitor must be connected to the two phases to which the temperature transmitter is connected. See the figure below.



Connection of capacitor

Colours of the conductors		
Conductor	**Flat cable**	**Single conductors**
1 = L1	Brown	Black
2 = L2	Black	Yellow
3 = L3	Grey	Red
4 = PE	Yellow and green	Green

The motors are wound for direct-on-line starting or star-delta starting, and the starting current is between four and six times the rated current of the motor.

The run-up time of the pump is only about 0.1 second. Direct-on-line starting is therefore normally approved by the power supply company.

6.1 Motor protection

6.1.1 Single-phase motors

Single-phase MS402 motors incorporate a thermal switch and require no additional motor protection. As an exception, the 1.1 kW (1.5 hp) MS402 requires external current protection.

DANGER
Electric shock
Death or serious personal injury

- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

DANGER
Electric shock
Death or serious personal injury

- The pump must be connected to protective earth.
- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

Single-phase MS4000 motors must be protected. A protective device can either be incorporated in a control box or be separate.

6.1.2 Three-phase motors

MS motors are available with or without a built-in temperature transmitter.

Motors with a built-in and operational temperature transmitter must be protected by:

- a motor-protective circuit breaker with thermal relay or
- an MP 204 motor protection unit and contactor(s).

Motors with or without a non-operational temperature transmitter must be protected by:

- a motor-protective circuit breaker with thermal relay or
- an MP 204 motor protection unit and contactor(s).

MMS motors have no built-in temperature transmitter. A Pt100 sensor is available as an accessory.

Motors with a Pt100 sensor must be protected by the following:

- a motor-protective circuit breaker with thermal relay or
- an MP 204 motor protection unit and contactor(s).

Motors without a Pt100 sensor must be protected by the following:

- a motor-protective circuit breaker with thermal relay with maximum trip class 10 according to IEC 60947-4-1 or
- an MP 204 motor protection unit and contactor(s).

6.1.3 Required settings of motor-protective circuit breaker

For motors with an MP 204 motor protection unit, Grundfos recommends using a special trip curve with P-characteristics at a setting of five times U_n for 1 second.

For cold motors, the tripping time for the motor-protective circuit breaker must be less than 10 seconds at five times the rated maximum current of the motor.

For all Grundfos submersible MMS motors, the maximum start and stop ramp time is 3 seconds (minimum 30 Hz).

If this requirement is not met, the motor warranty will be invalidated.

In order to ensure optimum protection of the submersible motor, set the motor-protective circuit breaker in accordance with the following:

1. Set the motor-protective circuit breaker to the rated maximum current of the motor.
2. Start the pump and let it run for half an hour at normal performance.
3. Slowly grade down the scale indicator until the motor trip point is reached.
4. Increase the setting by 5 %.

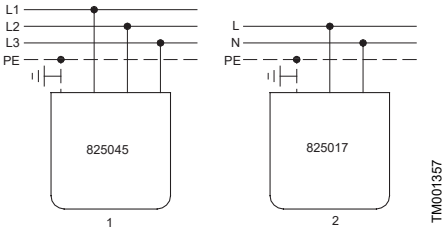
The highest permissible setting is the rated maximum current of the motor.

For motors wound for star-delta starting, the motor-protective circuit breaker must be set as above, but the maximum setting must be rated maximum current × 0.58.

The highest permissible startup time for star-delta starting or autotransformer starting is 2 seconds.

6.2 Lightning protection

The installation can be fitted with a special overvoltage protection device to protect the motor from voltage surges in the power supply lines if lightning strikes somewhere in the area. See fig. 8.



Connecting an overvoltage protective device

Pos.	Description
1	Three-phase
2	Single-phase

The overvoltage protective device will not protect the motor against a direct stroke of lightning.

Connect the overvoltage protective device to the installation as close as possible to the motor and always in accordance with local regulations. Ask Grundfos for lightning protective devices.

MS402 motors require no further lightning protection as they are highly insulated.

6.3 Cable sizing

Submersible motor cables are dimensioned for submersion in liquid and may not have sufficient cross-section for operation in open air.

Make sure that the submersible drop cable can withstand permanent submersion in the actual liquid and at the actual temperature.

The cross-section (q) of the cable must meet the following requirements:

- The submersible drop cable must be sized to the rated maximum current of the motor.
- The cross-section must be sufficient to make a voltage drop over the cable acceptable.

Grundfos supplies submersible drop cables for a wide range of installations. A cable sizing tool is available on Grundfos Insite at: https://www.grundfos.com/sp-system/download-sp-app-html.



Cable-sizing tool

The sizing tool provides an accurate calculation of the voltage drop at a given cross-section on the basis of the following parameters:

- cable length
- operating voltage
- full-load current
- power factor
- ambient temperature.

The voltage drop can be calculated both for direct-on-line and star-delta starting.

In order to minimise operating losses, the cable cross-section may be increased. This is only cost-efficient if the borehole provides the necessary space, and if the operating time of the pump is long. The cable sizing tool also provides a power loss calculator that shows the potential savings of an increased cross-section.

As an alternative to the cable-sizing tool, select the cross-section on the basis of the current values of the given cables.

The cross-section of the submersible drop cable must be large enough to meet the voltage quality requirements specified in the section on Electrical connection.

Determine the voltage drop for the cross-section of the submersible drop cable by means of the diagrams in the Appendix.

Use the following formula:

I: rated maximum current of the motor.

For star-delta starting, I is equal to the rated maximum current of the motor × 0.58.

Lx: length of cable converted to a voltage drop of 1 % of the nominal voltage.

$$Lx = \frac{\text{length of drop cable}}{\text{permissible voltage drop in \%}}$$

q: cross-section of submersible drop cable.

Draw a straight line between the actual I-value and the Lx-value. Where the line intersects the q-axis, select the cross-section that lies right above the intersection.

The diagrams are made on the basis of the formulas:

Single-phase submersible motor

$$L = \frac{U \times \Delta U}{I \times 2 \times 100 \times (\cos \varphi \times \frac{\rho}{q} + \sin \varphi \times Xl)}$$

Three-phase submersible motor

$$L = \frac{U \times \Delta U}{I \times 1.73 \times 100 \times (\cos \varphi \times \frac{\rho}{q} + \sin \varphi \times Xl)}$$

L	Length of submersible drop cable [m]
U	Rated voltage [V]
ΔU	Voltage drop [%]
I	Rated maximum current of the motor [A]
cos φ	0.9
ρ	Specific resistance: 0.025 [Ωmm^2/m]
q	Cross-section of submersible drop cable [mm^2]
sin φ	0.436
Xl	Inductive resistance: 0.078 × 10^{-3} [Ω/m].

Related information

6. Electrical connection

6.4 Control of single-phase MS402 motors

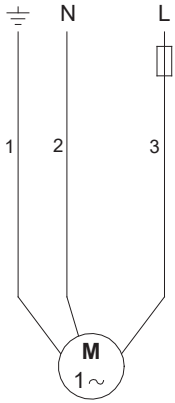
Single-phase MS402 motors smaller than 1.1 kW include motor protection that disconnects the motor if winding temperatures become excessive, even while voltage is still applied. Allow for this when the motor is part of a control system.

If a compressor is included in a control system together with an ochre filter, the compressor will run continuously once the motor protection has cut out the motor, unless other special precautions have been taken.

6.5 Connection of single-phase motors

6.5.1 2-wire motors

MS402 2-wire motors incorporate motor protection and a starter device and can therefore be connected direct to the mains. See the figure below.



TM001358

2-wire motors

Pos.	Description
1	Yellow and green
2	Blue
3	Brown

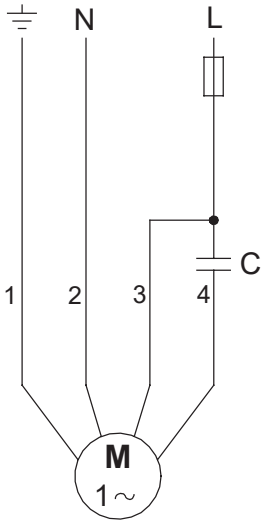
6.5.2 PSC motors

The PSC motors are connected to the mains via a run capacitor which must be sized for continuous operation.

Select the correct capacitor size from the table below:

Motor [kW]	Capacitor [µF] 400 V, 50 Hz
0.25	12.5
0.37	16
0.55	20
0.75	30
1.10	40
1.50	50
2.20	75

MS402 PSC motors smaller than 1.1 kW incorporate motor protection and must be connected to the mains as shown in the figure below.



TM001359

PSC motors

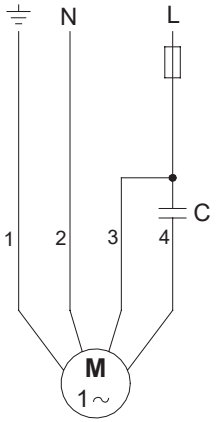
Pos.	Description
1	Yellow and green
2	Grey
3	Brown
4	Black

6.5.3 3-wire motors

MS402 3-wire single-phase motors include built-in motor protection and must be connected to the mains through a Grundfos SA-SPM control box (50 Hz or 60 Hz) without motor protection.

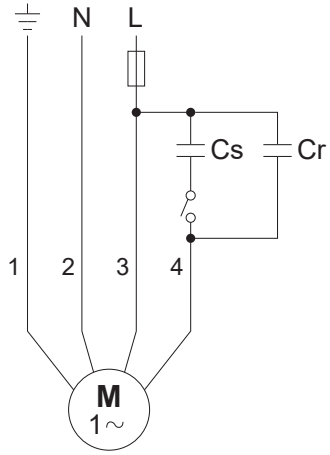
MS4000 and MS6000 3-wire single-phase motors must be connected to the mains through a Grundfos SA-SPM control box (50 Hz or 60 Hz) that incorporates motor protection.

If a conventional motor-protective circuit breaker is used, the electrical connection must be carried out as described below.



TM001359

CSIR



TM074265

CSCR

6.6 Connection of three-phase motors

Three-phase motors must be protected. See the section on three-phase motors.

For electrical connection via the MP 204, see the separate installation and operating instructions for this unit.

When a conventional motor-protective circuit breaker is being used, the electrical connection must be carried out as described below.

Related information

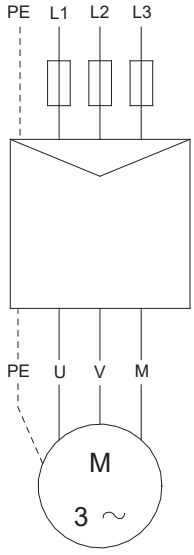
6.1.2 Three-phase motors

6.6.1 Motors wound for direct-on-line starting

The connection of Grundfos submersible motors wound for direct-on-line starting is described in the table below and the figure below.

Mains	Cable/connection
	Grundfos 4" and 6" motors
PE	PE (yellow and green)
L1	U (brown)
L2	V (black)
L3	W (grey)

Check the direction of rotation as described in the section on Connection of three-phase motors.



Grundfos motors - direct-on-line starting

Related information

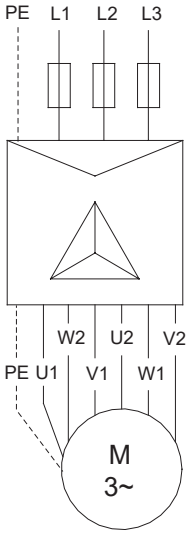
6.6 Connection of three-phase motors

6.6.2 Motors wound for star-delta starting

The connection of Grundfos submersible motors wound for star-delta starting is described in the table and figure below.

Connection	Grundfos 6" motors
PE	Yellow and green
U1	Brown
V1	Black
W1	Grey
W2	Brown
U2	Black
V2	Grey

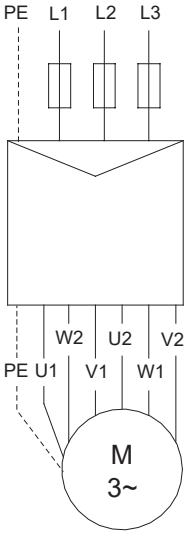
Check the direction of rotation as described in the section on Connection of three-phase motors.



TM032100

Grundfos motors wound for star-delta starting

If direct-on-line starting is required, the motors must be connected as shown in the figure below.



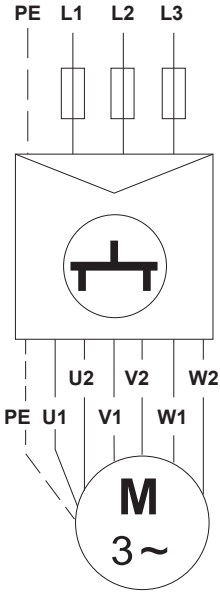
TM032101

Grundfos motors wound for star-delta starting - direct-on-line starting

Related information

6.6 Connection of three-phase motors

6.6.3 MS6000P synchronous motors requiring double cabling



TM076468

Grundfos MS6000P 37 kW and 45 kW

6.6.4 Connection in the case of unidentified cable marking or connection

If it is unknown where the individual conductors are to be connected to the mains in order to ensure the correct direction of rotation, proceed as follows:

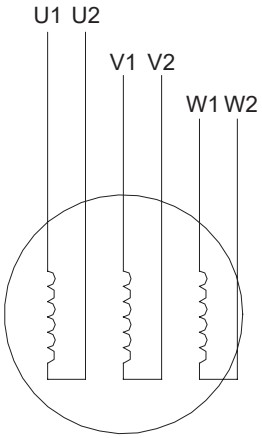
Motors wound for direct-on-line starting

Connect the pump to the mains as is expected to be right.

Then check the direction of rotation as described in the section on Connection of three-phase motors.

Motors wound for star-delta starting

Determine the windings of the motor by means of an ohmmeter and name the conductor sets for the individual windings accordingly: U1-U2, V1-V2, W1-W2. See the figure below.



TM001367

Unidentified cable marking or connection - motors wound for star-delta starting

If star-delta starting is required, connect the conductors as shown in the figure Grundfos motors wound for star-delta starting.

If direct-on-line starting is required, connect the conductors as shown in the figure Grundfos motors wound for star-delta starting - direct-on-line starting.

Then check the direction of rotation as described in the section on Connection of three-phase motors.

Related information

6.6 Connection of three-phase motors

6.6.2 Motors wound for star-delta starting

6.6.5 Checking the direction of rotation

The pump must not be started until the suction interconnector has been completely submerged in the liquid.

When the pump has been connected to the power supply, check the direction of rotation:

1. Start the pump and measure quantity of water and head.
2. Stop the pump and interchange two phases.
3. Start the pump and measure quantity of water and head.
4. Stop the pump.
5. Compare the two results. The connection giving the larger quantity of water and the higher head is the correct one.

6.6.6 Soft starter

Grundfos only recommends the use of soft starters which control the voltage on all three phases and which are provided with a bypass switch.

Ramp times: maximum 3 seconds.

For further details, contact your soft starter supplier or Grundfos.

6.6.7 Frequency converter operation

Three-phase MS motors can be connected to a frequency converter. The technology of Grundfos CUE or RSI frequency converters allows their use without output filters for low voltage and short cable lengths. It also allows their use with a sine-wave filter for cable lengths up to 500 m. Refer to the table CUE/RSI Supply and cable length limits below.

During frequency converter operation, it is not advisable to run the motor at a frequency higher than the rated frequency (50 or 60 Hz). In connection with pump operation, it is important never to reduce the frequency (and consequently the speed) to such a level that the necessary flow of cooling liquid past the motor is no longer ensured.

To enable the monitoring of the motor temperature, Grundfos recommends that a Pt100 or Pt1000 sensor is installed.

If an MS motor with temperature transmitter is connected to a frequency converter, a fuse incorporated in the transmitter will melt and the transmitter will be inactive. The transmitter cannot be reactivated. This means that the motor will operate like a motor without a temperature transmitter.

To avoid damage to the pump part, make sure that the motor stops when the pump flow falls below 0.1 × rated flow.

Voltage peaks for Grundfos submersible motors should be limited in accordance with the table below.

Motor type	Max. U peak voltage	Max. dU/dt
MS402 [3]	650 V line-to-line [4]	2000 V/µs
MS4000	850 V line-to-line	6000 V/µs
MS6000 and MS6000P	1500 V line-to-line	6000 V/µs
MMS6	850 V line-to-ground	500 V/µs
MMS8000 and MMS8000P	850 V line-to-ground	500 V/µs
MMS10000	850 V line-to-ground	500 V/µs
MMS12000	850 V line-to-ground	500 V/µs

3) MS402 575V/60Hz motors have 6000 V/us and 850 V limits

4) 800 VDC open circuit voltage for solar application

For asynchronous motors:

Permissible frequency ranges:

- 30-50 Hz
- 30-60 Hz.

Ramp times: maximum 3 seconds from standstill to minimum frequency and vice versa.

For synchronous motors MS6000P and MMS8000P:

Permissible frequency ranges:

- 55-100 Hz
- 55-120 Hz.

Ramp times: maximum 3 seconds from standstill to minimum frequency and vice versa.

Depending on the type, the frequency converter may cause increased acoustic noise from the motor. Furthermore, it may expose the motor to detrimental voltage peaks. This can be abated by installing an LC filter, or preferably a sinus filter, between the frequency converter and the motor.

For further details, contact your frequency converter supplier or Grundfos.

CUE/RSI supply and unscreened cable length limits

Operating with CUE/RSI						
Motor type [5]	Without filter			With sine-wave filter		
	Max. supply to CUE/RSI		Maximum unscreened cable length	Max. supply to CUE/RSI		Maximum unscreened cable length
	[VAC] [6]	[VDC] [7]	[m]	[VAC] [6]	[VDC] [7]	[m]
MS402	240	400	100	460 [8]	800	300 [8]
MS4000	240	400	100	575/500 [9]	800	500
MS6000	460	400	300	575/500 [9]	800	500
MS6000P	240	-	300	575/500 [9]	800	500
MMS	-	-	-	690/500 [9]	800	500

5) Motors operating within their temperature rating

6) Single-phase or three-phase AC supply (rms voltage)

7) VDC open circuit voltage in solar application

8) Supporting up to 500 m cable length when used with a sine-wave filter and supplied with up to 575 VAC or 800 VDC

9) 575 V or 690 V for CUE and 500 V for RSI

6.6.8 Requirements for SPE and MS6000P to operate without sine-wave filter

The MS6000P synchronous permanent magnet motor has been improved with upgraded insulation. As a result, a sine-wave filter is not necessary if all the requirements in the table below are fulfilled.

The SPE pump systems with MS6000P motor supplied by Grundfos meet the VFD and motor input requirements. Therefore, they do not require a sine-wave filter when the application and grid requirements are fulfilled.

Requirements for the MS6000P to operate without sine-wave filter

	Value	Unit	Grundfos SPE systems with MS6000P [10]
Application requirements			
Max. liquid temperature	60/140	[°C/°F]	Must be met
Max. cable length	300/1000	[m/ft]	Must be met
Grid requirements			
Max. line-line voltage	460	[V RMS]	Must be met
Phases	3	[-]	Must be met
VFD requirements			
Max. DC voltage	620	[V_{DC}]	✔
Max. peak voltage at inverter terminals	650	[V_{LL}]	✔
Min. rise time at VFD terminals (10-90 % V_{DC})	100	[ns]	✔
Max. dU/dt at VFD terminals	5	[V/ns]	✔
Max. switching frequency	4	[kHz]	✔
Grid voltage rectification	Passive rectifier bridge		✔
Motor input requirements			
Max. peak voltage at terminals	1500	[V_{LL}]	✔
Max. dU/dt at motor terminals	6	[V/ns]	✔

10) SP pump + MS6000P + CUE

- Local and national requirements for safety and electromagnetic interference (EMI) must always be followed. Such requirements may demand filtering due to, for example. electromagnetic compatibility or noise suppression.
- Cables and other system components must be properly rated for VFD use.
- If the cables are longer than 300 m/ 1000 ft and/or the grid voltage is higher than 460 V, a sine-wave filter must still be used.

7. Setting up the CUE frequency converter in an SPE system

The SPE system consists of the following:

- SPE pump set
  - SP pump
  - MS6000P or MS8000P motor
- CUE frequency converter.
- sine-wave filter (when required).

The CUE has a start up guide. Follow the instructions on the display to set up the pump, the motor and the application.

For further information regarding safety and advanced settings, see the CUE Installation and operating instructions.

Installation and operating instructions
http://net.grundfos.com/qr/i/96780034

7.1 Compensation for long cables

To compensate for the impact of the cable being long, Automatic Motor Adaption (AMA) may be required. In this case, after completing the default setup through the start-up guide, complete the following steps:

1. If a sine-wave filter is installed, disconnect it and connect the motor directly to the CUE.
2. Go to parameter 1-29 "Automatic Motor Adaptation (AMA)" and select [1] Enable complete AMA.
3. Press [Hand on] to start the AMA.
4. Reconnect sine-wave filter if installed.

7.2 System without sine-wave filter

For SPE systems with MS6000P with all relevant requirements fulfilled and a sine-wave filter not installed, go to parameter 14-55 "Output Filter" and select [0] No Filter.

SPE systems with MMS8000P always require a sine-wave filter.

8. Mechanical installation

WARNING
Sharp element
Death or serious personal injury



- When mounting the facilitating pipe, wear personal protective equipment to prevent injuries from sharp edges on the pump.

WARNING
Contamination when pumping drinking water
Death or serious personal injury



- Before the pump is used for supplying drinking water, flush the pump thoroughly with clean water.
- Do not use the pump for drinking water if the internal parts have been in contact with particles or substances not suitable for water intended for human consumption.



The pump must be installed according to national water regulations and standards.



Be careful not to bend or damage long pump sets, when moving them from horizontal to vertical positions.

8.1 Removing and fitting the cable guard

The cable guard is screwed on to the pump, it must be removed and fitted by means of screws. See appendix.



Make sure that the pump chambers are aligned when the cable guard has been fitted.

8.2 Fitting of the submersible drop cable and motor cable

Before connecting the submersible drop cable to the motor, make sure that the cable socket is clean and dry.

To facilitate the connection of the cable, lubricate the rubber parts of the cable plug with non-conducting silicone paste.

Tighten the screws holding the cable to the torques stated [Nm]:

MS402:	3.1 Nm
MS4000:	3.0 Nm
MS6000/MS6000P:	4.5 Nm
MMS6:	20 Nm
MMS8000/MS8000P:	18 Nm
MMS10000:	18 Nm
MMS12000:	15 Nm

Connect the motor cable to the drop cable by use of original Grundfos cable termination kits, such as shrink tube type KM, or cable termination kit type M0 to M4.

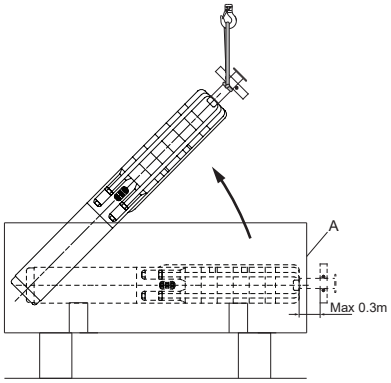
If necessary, shorten the motor cable to ensure that it is always covered with pump medium prior to making the cable jointing as described above.

Staybolt diameter	Torque [Nm]
5/16 UNF	18
1/2 UNF	50
M8	18
M12	70
M16	150
M20	280

Staybolt diameters and torques

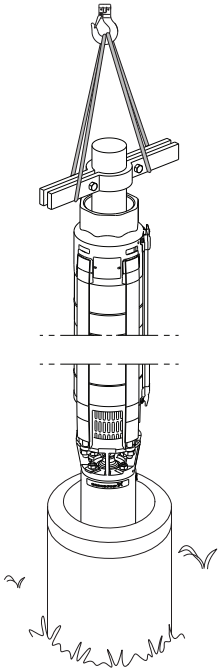
8.3 Lifting the product

Grundfos recommends fitting a maximum 30 cm long pipe to the pump to facilitate handling of the pump during installation.



Lifting the pump set into vertical position

Lift the pump set by means of pipe clamps fitted to the riser pipe. See the figure below.



Lifting the pump set into position

8.4 Riser pipe

WARNING
Sharp element
Death or serious personal injury

- When mounting the riser pipe, wear personal protective equipment to prevent injuries from sharp edges on the pump.

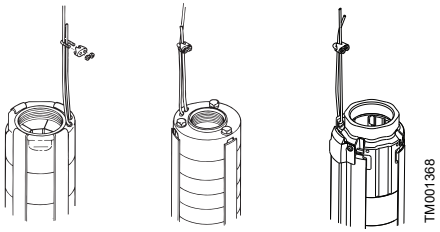
If a tool, for example a chain pipe wrench, is used when the riser pipe is fitted to the pump, the pump must only be gripped by the pump outlet chamber.

The threaded joints on the riser pipe must all be well cut and fit together to prevent loosening when subjected to torque reaction caused by the starting and stopping of the pump.

The thread on the first section of the riser pipe, which is to be screwed into the pump, must not be longer than the threads in the pump.

Plastic pipes are recommended for 4" pumps only.

When plastic pipes are used, secure the pump by an unloaded straining wire to be fastened to the outlet chamber of the pump. See the figure below.



Fixing the straining wire

When connecting plastic pipes, use a compression coupling between the pump and the first pipe section.

From 6" to 10" pumps there is no hook or connection eye for straining wire.

When flanged pipes are used, the flanges must be slotted to take the submersible drop cable and a water indicator hose, if fitted.

Maximum installation pressure [mWC]

Grundfos MS402:	150
Grundfos MS4000:	600
Grundfos MS6000:	600
Grundfos MS6000P:	600
Grundfos MMS:	600

8.5 Placing in borehole

WARNING
Crushing of hands and feet
Death or serious personal injury

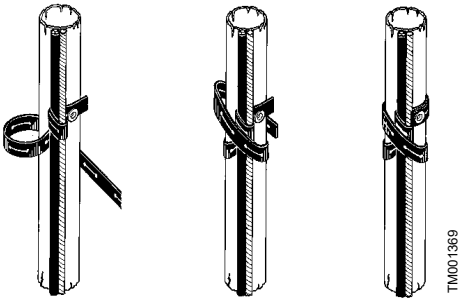
- Stay clear of the wire and cable during placement in borehole.

8.6 Cable clips

Fit cable clips every 3 m to fix the submersible drop cable and the straining wire, if fitted, to the riser pipe of the pump.

Grundfos supplies cable clip sets on request.

1. Cut off the rubber band so that the section without a slit is as long as possible.
2. Insert a button in the first slit.
3. Position the wire alongside the submersible drop cable as shown in the figure below.



Fitting the cable clips

4. Wind the band once around the wire and the cable. Then wind it tightly at least twice around the pipe, wire and cable.
5. Push the slit over the button, and cut off the band.

When using cables with a large cross-section, the band must be wound several times.

For plastic pipes, leave some slack between each cable clip, as plastic pipes expand when loaded.

When flanged pipes are used, the cable clips must be fitted above and below each joint.

8.7 Lowering the pump

DANGER
Electric shock
Death or serious personal injury

- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

Do not lower or lift the pump by means of the motor cable.

Grundfos recommends checking the borehole by means of an inside calliper before lowering the pump to ensure unobstructed passage.

Lower the pump carefully into the borehole, taking care not to damage the motor cable and the submersible drop cable.

8.8 Installation depth

The dynamic water level must always be above the suction interconnector of the pump. See the section on Positional requirements and the figure Comparison of various water levels in section 9.1.

Minimum inlet pressure is indicated in the NPSH curve for the pump. The minimum safety margin must be 0.5 m head.

We recommend that you install the pump so that the motor part is above the well screen in order to ensure optimum cooling. See the section on Liquid temperatures and motor cooling.

When the pump has been installed to the required depth, the installation must be finished by means of a borehole seal.

Loosen the straining wire so that it becomes unloaded and lock it to the borehole seal by means of wire locks.

For pumps fitted with plastic pipes, the expansion of the pipes when loaded must be taken into consideration, when deciding on the installation depth of the pump.

Related information

5.2 Positional requirements
5.4 Liquid temperatures and motor cooling
9.1 Startup

9. Startup and operation

DANGER
Electric shock
Death or serious personal injury

- The pump must be connected to protective earth.
- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

9.1 Startup

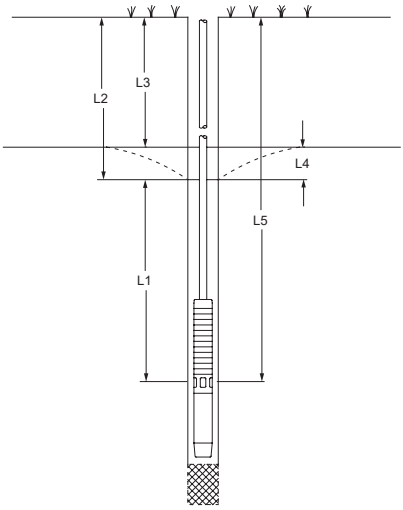
When the pump has been connected correctly and it is submerged in the liquid to be pumped, it must be started with the outlet valve closed off to approximately 1/3 of its maximum volume of water.

Check the direction of rotation as described in the section on Connection of three-phase motors.

If there are impurities in the water, open the valve gradually as the water becomes clearer. Do not stop the pump until the water is completely clear, otherwise the pump parts and the non-return valve may become blocked.

As the valve is being opened, check the drawdown of the water level to ensure that the pump always remains submerged.

The dynamic water level must always be above the suction interconnector of the pump. See the section on Positional requirements and the figure below.



Comparison of various water levels

L1: Minimum installation depth below the dynamic water level. We recommend at least 0.5 m, or as specified by the NPSH curve for the relevant pump.

L2: Depth to dynamic water level.

L3: Depth to static water level.

L4: Drawdown. This is the difference between the dynamic and the static water levels.

L5: Installation depth.

If the pump can pump more than yielded by the well, we recommend that you install the Grundfos MP 204 motor protector or some other type of dry-running protection.

If no water level electrodes or level switches are installed, the water level may be drawn down to the suction interconnector of the pump and the pump will then draw in air.

Long time of operation with water containing air may damage the pump and cause insufficient cooling of the motor.

Related information

5.2 Positional requirements
6.6 Connection of three-phase motors

9.2 Operation

9.2.1 Min. flow rate

To ensure the necessary cooling of the motor, the pump flow velocity must never be set so low that the cooling requirements in the section on Liquid temperatures and motor cooling cannot be met.

Related information

5.4 Liquid temperatures and motor cooling

9.2.2 Operating range

The pump must never run outside the rated pump curve - see Data Booklet.

9.2.3 Frequency of starts and stops

Minimum number of starts	
MS and MMS	1 per year

Maximum number of starts	
MS402	100 per hour 300 per day
MS4000	100 per hour 300 per day
MS6000	30 per hour 300 per day
MS6000P	120 per hour 360 per day
MMS6	10 per hour 70 per day
MMS8000	8 per hour 60 per day
MMS8000P	30 per hour 90 per day
MMS10000	6 per hour 50 per day
MMS12000	5 per hour 40 per day

10. Service

All pumps are easy to service.

Service kits and service tools are available from Grundfos.

The pumps can be serviced at a Grundfos service centre.

If Grundfos is requested to service the pump, Grundfos must be contacted with details about the pumped liquid, etc. before the pump is returned for service. Otherwise Grundfos can refuse to accept the pump for service.

Possible costs of returning the pump are paid by the customer.

Additional service documentation including service videos are available in Grundfos Product Center > http://product-selection.grundfos.com/.



DANGER
Electric shock
Death or serious personal injury

- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.



DANGER
Toxic or radio active liquid
Death or serious personal injury

- If a pump has been used for a liquid which is injurious to health or toxic, the pump will be classified as contaminated.



WARNING
Sharp element
Death or serious personal injury

- For service, see Service instructions. Must be performed by qualified persons.

10.1 SPE

The following is only valid for SPE pump sets.



DANGER
Magnetic field
Death or serious personal injury

- Do not handle the rotor if having a pacemaker.



DANGER
Crushing of hands
Death or serious personal injury

- Keep the rotor surroundings free of magnetic objects and be careful when placing the rotor on a magnetic surface.



DANGER
Electric shock
Death or serious personal injury

- Make sure that motor cable ends are not live before starting work on the product.
- Make sure that the power supply cannot be accidentally switched on.

In case of unintended water flow through a non-energized pump, there is a risk that the moving parts of the pump and the motor may start rotating, and generate voltage over the terminals. The size of the voltage depends on the rotation speed. Therefore, the motor terminals must be considered as live until proven otherwise.

11. Fault finding



DANGER
Electric shock
Death or serious personal injury
- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.



DANGER
Toxic or radio active liquid
Death or serious personal injury
- If a pump has been used for a liquid which is injurious to health or toxic, the pump will be classified as contaminated.

11.1 SPE

The following is only valid for SPE pump sets.



DANGER
Magnetic field
Death or serious personal injury
- Do not handle the rotor if having a pacemaker.



DANGER
Crushing of hands
Death or serious personal injury
- Keep the rotor surroundings free of magnetic objects and be careful when placing the rotor on a magnetic surface.



DANGER
Electric shock
Death or serious personal injury
- Make sure that motor cables ends are not live before starting work on the product.
- Make sure that the power supply cannot be accidentally switched on.

In case of unintended flow of water through a non-energized pump there is a risk that the moving parts of the pump and the motor will start rotating, thereby generating voltage over the terminals. The size of the voltage depends on the speed of rotation. Due to this, the motor terminals must be considered as live until proven otherwise.

11.1.1 The pump does not run.

The pump does not run.

Cause	Remedy
The fuses are blown.	Replace the blown fuses. If the new ones blow too, check the electric installation and the submersible drop cable.
The ELCB or the voltage-operated ELCB has tripped.	Cut in the circuit breaker.
No power supply.	Contact the power supply company.
The motor-protective circuit breaker has tripped.	Reset the motor-protective circuit breaker (automatically or possibly manually). Check the voltage if it trips again. If the voltage is correct, see items 1 e) to 1 h).
The motor-protective circuit breaker or the contactor is defective.	Replace the motor-protective circuit breaker or the contactor.
Starter device is defective.	Repair or replace the starter device.
The control circuit has been interrupted or is defective.	Check the electric installation.
The dry-running protection has cut off the power supply to the pump due to low water level.	Check the water level. If it is correct, check the water level electrodes or level switches.
The pump or the submersible drop cable is defective.	Repair or replace the pump or cable.

11.1.2 The pump runs but gives no water.

The pump runs but gives no water.

Cause	Remedy
The outlet valve is closed.	Open the valve.
No water or too low water level in borehole.	See item 3 a).
The non-return valve is stuck in closed position.	Pull out the pump and clean or replace the valve.
The inlet strainer is blocked.	Pull out the pump and clean the strainer.
The pump is defective.	Repair or replace the pump.

11.1.3 The pump runs at reduced performance.

The pump runs at reduced performance.

Cause	Remedy
The drawdown is larger than anticipated.	Increase the installation depth of the pump, throttle the pump or install a pump with a lower performance.
Wrong direction of rotation.	See section *Connection of three-phase motors*.
The valves in the outlet pipe are partly closed or blocked.	Clean or replace the valves.
The outlet pipe is partly blocked by impurities (ochre).	Clean or replace the pipe.
The non-return valve of the pump is partly blocked.	Pull out the pump and clean or replace the valve.
The pump and the riser pipe are partly blocked by impurities (ochre).	Pull out the pump and clean or replace it. Clean the pipes.
The pump is defective.	Repair or replace the pump.
Leakage in the pipes.	Check and repair the pipes.
The riser pipe is defective.	Replace the pipe.

Related information

6.6 Connection of three-phase motors

11.1.4 Frequent starts and stops.

Frequent starts and stops.

Cause	Remedy
The difference between the start and stop pressures is too small.	Increase the difference. The stop pressure must not exceed the operating pressure of the pressure tank, and the start pressure must be high enough to ensure sufficient water supply.
The water level electrodes or level switches in the reservoir have not been installed correctly.	Adjust the intervals of the electrodes or level switches to ensure suitable time between the cutting-in and cutting-out of the pump. See installation and operating instructions for the electrodes or level switches. If the intervals between stop and start cannot be changed via the automatics, the pump performance may be reduced by throttling the outlet valve.
The non-return valve is leaking or stuck half-open.	Pull out the pump and clean or replace the valve.
The precharge pressure of the tank is too low.	Adjust the precharge pressure of the tank in accordance with its installation and operating instructions.
The tank is too small.	Increase the capacity of the tank by replacing it or supplementing it with an additional tank.
The diaphragm of the tank is defective.	Check the diaphragm tank.

12. Checking motor and cable



DANGER
Electric shock
Death or serious personal injury

- Switch off the power supply before starting any work on the product.
- Make sure that the power supply cannot be accidentally switched on.

12.1 SPE

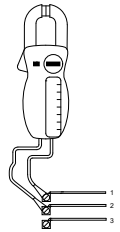
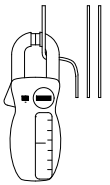
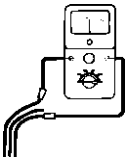
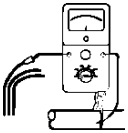
The following is only valid for SPE pump sets.



DANGER
Electric shock
Death or serious personal injury

- Make sure that motor cables ends are not live before starting work on the product.
- Make sure that the power supply cannot be accidentally switched on.

In case of unintended flow of water through a non-energized pump there is a risk that the moving parts of the pump and the motor will start rotating, thereby generating voltage over the terminals. The size of the voltage depends on the speed of rotation. Due to this, the motor terminals must be considered as live until proven otherwise.

1. Supply voltage  TM001371	Measure the voltage between the phases by means of a voltmeter. On single-phase motors, measure between phase and neutral or between two phases, depending on the type of supply. Connect the voltmeter to the terminals in the motor-protective circuit breaker.	The voltage must, when the motor is loaded, be within the range specified in the section on Electrical connection. The motor may burn if there are larger variations in voltage. Large variations in voltage indicate poor power supply, and the pump must be stopped until the defect has been remedied.
2. Current consumption  TM001372	Measure the amps of each phase while the pump is operating at a constant outlet head (if possible, at the performance where the motor is most heavily loaded). For maximum operating current, see nameplate.	For three-phase motors, the difference between the current in the phase with the highest and lowest phase consumption must not exceed 5 %. If this limit is exceeded, or if the current surpasses the rated value, the following faults may occur: • The contacts of the motor-protective circuit breaker are burnt. Replace the contacts or the control box for single-phase operation. • Poor connection in conductors, possibly in the cable joint. See item 3. • Too high or too low supply voltage. See item 1. • The motor windings are short-circuited or partly disjointed. See item 3. • Damaged pump is causing the motor to be overloaded. Pull out the pump for overhaul. • The resistance value of the motor windings deviates too much (three-phase). Move the phases in phase order to a more uniform load. If this does not help, see item 3.
Items 3 and 4: Measurement is not necessary when the supply voltage and the current consumption are normal.		
3. Winding resistance  TM001373	Disconnect the submersible drop cable from the motor-protective circuit breaker. Measure the winding resistance between the conductors of the drop cable.	For three-phase motors, the deviation between the highest and the lowest value must not exceed 10 %. If the deviation is higher, pull out the pump. Measure motor, motor cable and drop cable separately, and repair or replace defective parts. **Note:** The operating winding of single-phase 3-wire motors will assume the lowest resistance value.
4. Insulation resistance  TM001374	Disconnect the submersible drop cable from the motor-protective circuit breaker. Measure the insulation resistance from each phase to earth (frame). Make sure that the earth connection was made carefully.	If the insulation resistance is less than 0.5 MΩ, the pump must be pulled out for motor or cable repair. Local regulations may specify other values for the insulation resistance.

Related information

6. Electrical connection

13. Disposing of hazardous or toxic materials



DANGER
Toxic or radio active liquid
Death or serious personal injury

- If a pump has been used for a liquid which is toxic or injurious to health, the pump will be classified as contaminated.

14. Disposing of the product

This product or parts of it must be disposed of in an environmentally sound way.

1. Use the public or private waste collection service.
2. If this is not possible, contact the nearest Grundfos company or service workshop.



The crossed-out wheelie bin symbol on a product means that it must be disposed of separately from household waste. When a product marked with this symbol reaches its end of life, take it to a collection point designated by the local waste disposal authorities. The separate collection and recycling of such products will help protect the environment and human health.

See also end-of-life information at *www.grundfos.com/product-recycling*.

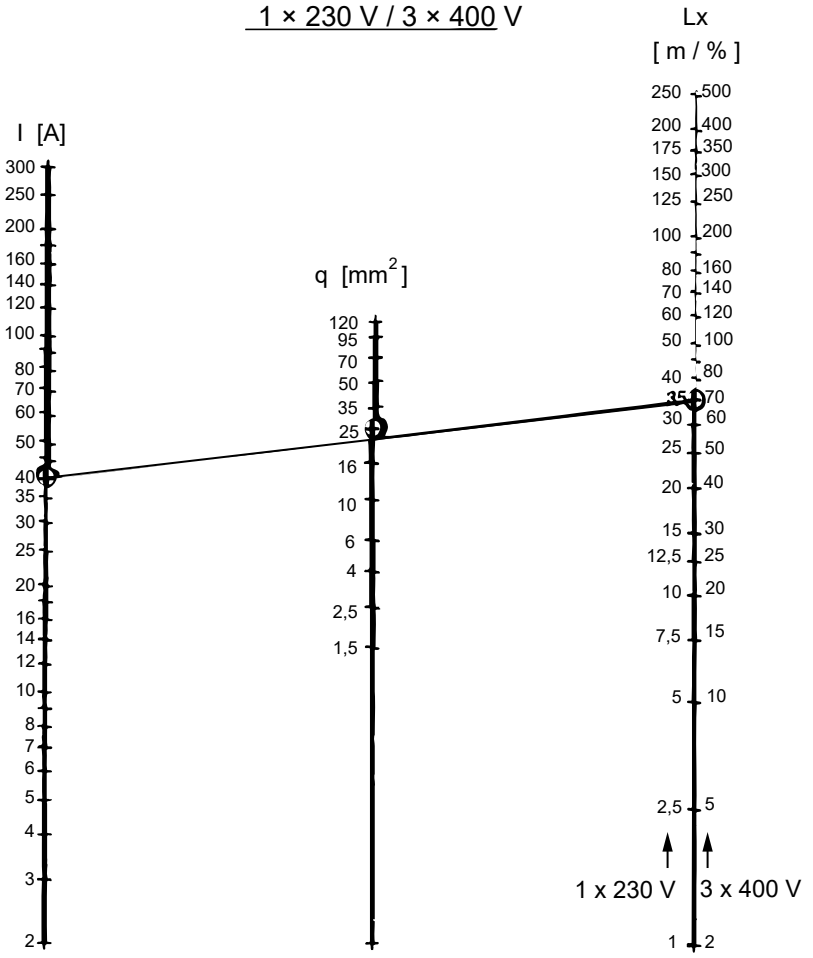
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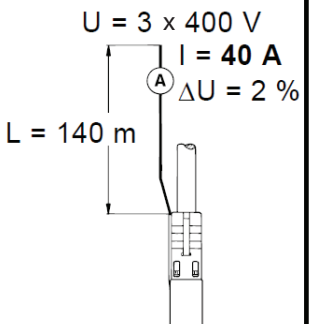
Appendix A

A.1. Appendix



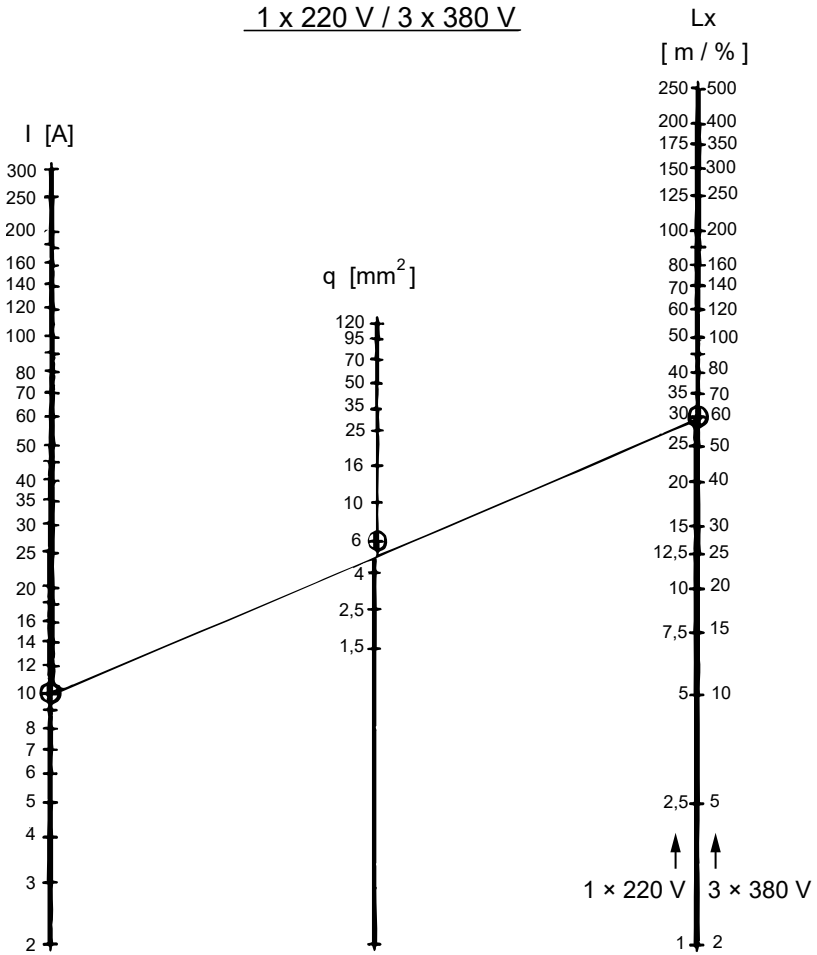
Example:

U = 3 x 400 V
I = **40 A**
L = 140 m
ΔU = 2 %



$$Lx = \frac{L}{\Delta U} = \frac{140}{2\ \%} = \mathbf{70\ m} = q \Rightarrow 25\ mm^2$$

8394

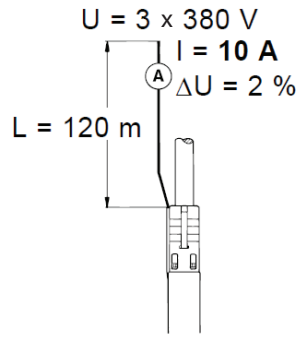


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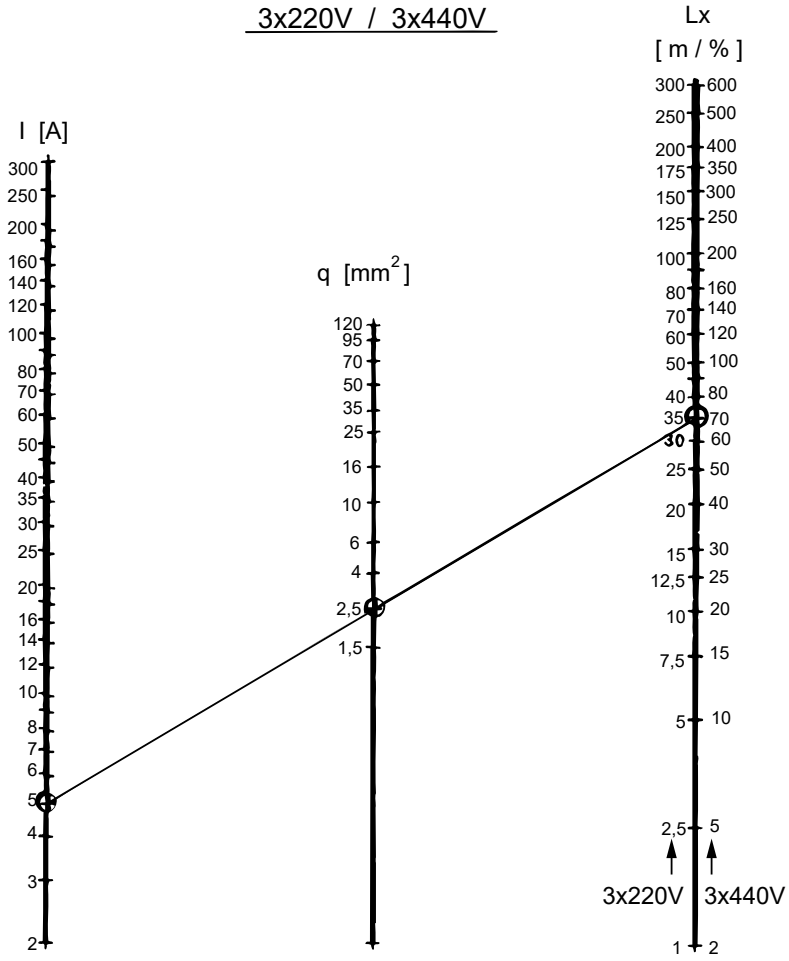
Example:

U = 3 x 380 V
I = **10 A**
L = 120 m
ΔU = 2 %

$$Lx = \frac{L}{\Delta U} = \frac{120}{2\ \%} = \mathbf{60\ m} = q \Rightarrow 6\ mm^2$$



1SDC078395

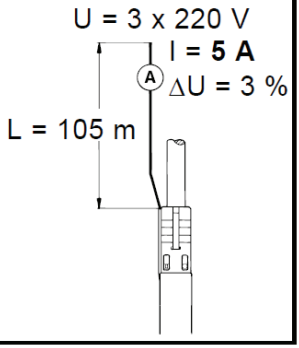


TM001348

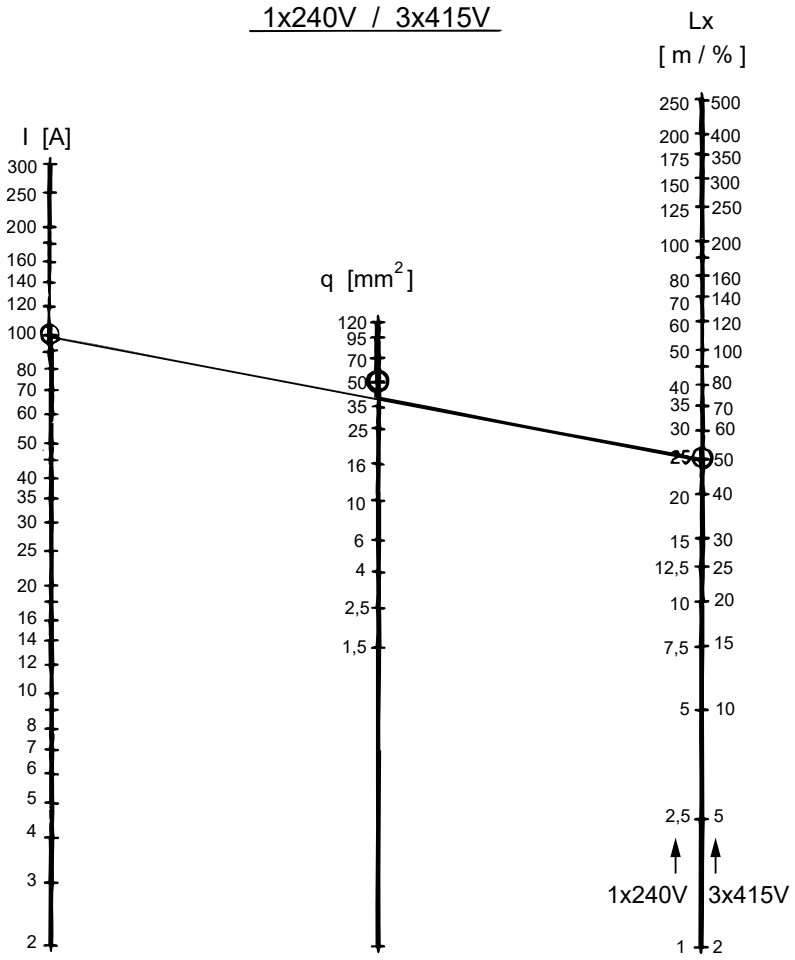
Example:

U = 3 x 220 V
I = **5 A**
L = 105 m
ΔU = 3 %

$$Lx = \frac{L}{\Delta U} = \frac{105}{3\ \%} = \mathbf{35\ m} = q \Rightarrow 2{,}5\ mm^2$$



TM078396

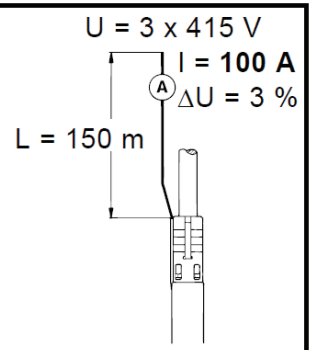


TM001347

Example:

U = 3 x 415 V
I = **100 A**
L = 150 m
ΔU = 3 %

$$Lx = \frac{L}{\Delta U} = \frac{150}{3\ \%} = \mathbf{50\ m} = q \Rightarrow 50\ mm^2$$



TM078397

A.2. Appendix

SP 1 - SP 2 - SP 3 - SP 5

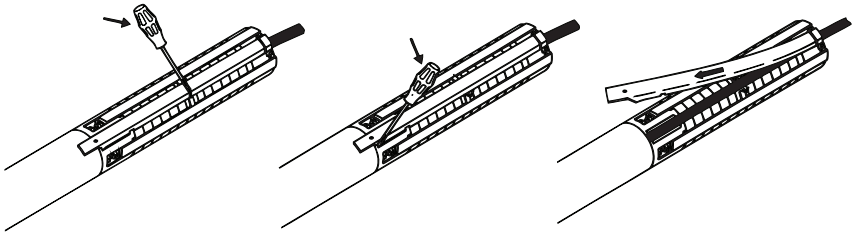


Fig.1 Fig.2 Fig.3

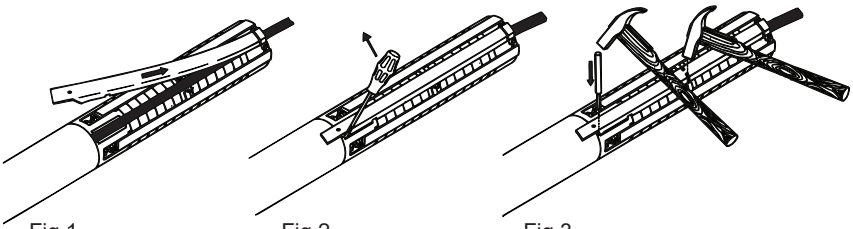


Fig.1 Fig.2 Fig.3

TM078409

SP 7 - SP 9 - SP 11 - SP 14 - SP 17 - SP 30 - SP 46 - SP 60

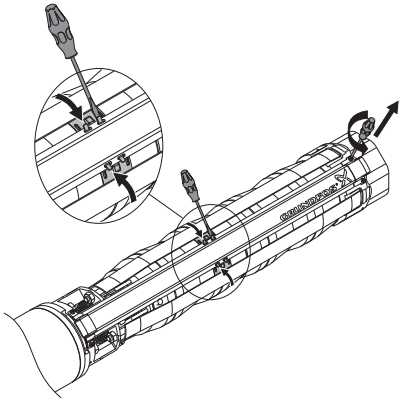


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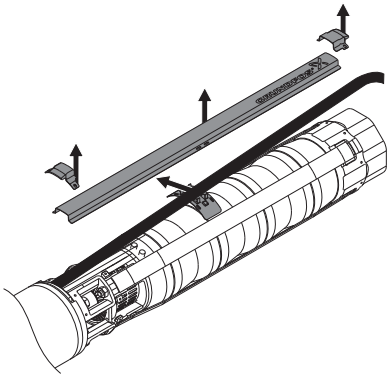


Fig.2

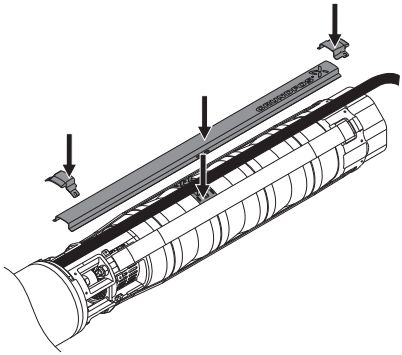


Fig.1

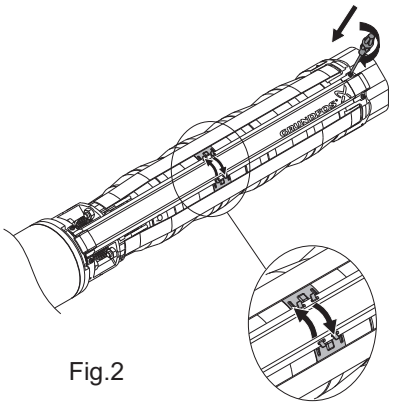


Fig.2

TM0178411

SP 77 - SP 95 - SP 125 - SP 160- SP 215

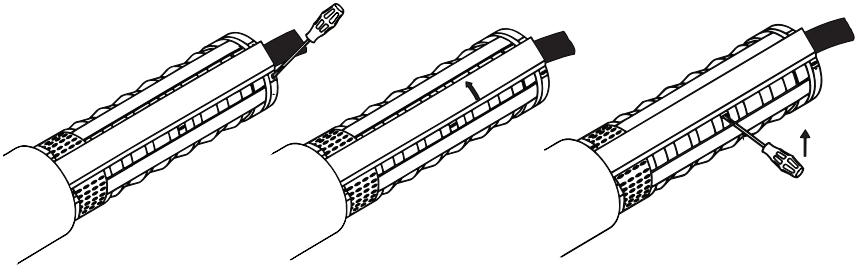


Fig.1 Fig.2 Fig.3

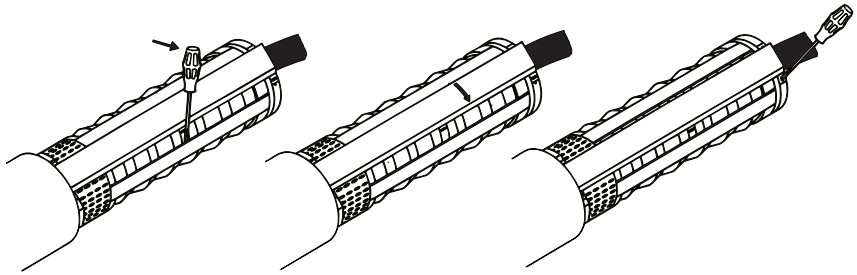


Fig.1 Fig.2 Fig.3

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