MS6000

Submersible motors 50/60 Hz

GRUNDFOS

Table of contents

1. Product description

The Grundfos MS6000 product range is a complete range of asynchronous submersible motors from 4 kW up to 30 kW in 50 and 60 Hz versions and synchronous submersible motors from 4 Kw to 45 kW in 3000 rpm and 3600 rpm versions.

The following material versions are available:

- a standard version made of stainless steel EN 1.4301 (AISI 304)
- an R-version made of stainless steel EN 1.4539 (AISI 904L) for aggressive liquids such as seawater and mine water.

The Grundfos MS6000 submersible motors are designed according to market standards. All Grundfos MS6000 motors are designed to fit pump ends manufactured in compliance with the NEMA standards, therefore, they can be fitted on all Grundfos SP pumps without adapters. The motors are also available with a flange extension allowing for fitting pump ends from other manufacturers.

General characteristics of the MS6000 motor:

- outside diameter (OD): 6 in (139.5 mm)
- high efficiency
- stator completely encapsulated in stainless steel
- cooling by pumped liquid
- hermetically sealed, canned motor with a dry stator
- enclosure class IP68
- factory fill with Grundfos motor liquid SML-3, alternatively with demineralized water
- built-in temperature transmitter (Tempcon) on the asynchronous motors.

The motor temperature can also be monitored via a Pt100 sensor (used for frequency controlled installations).

GR-1015370

MS6000 motor without flange extension

GR-1015371

MS6000 motor with flange extension

Features and benefits

The Grundfos MS6000 standard asynchronous and MS6000P synchronous submersible motors offer the following features and benefits:

- High motor efficiency
  The complete motor range is characterized by high efficiency contributing to improved economy of the entire pump system. The motor efficiency of synchronous motors is approximately 10 % higher than the efficiency of asynchronous motors.
- Sealing system
  All motors are equipped with mechanical shaft seals.
- High reliability
  State-of-the-art shaft seal design and materials offer high wear resistance, long operating life and improved sticking capabilities.
- Super stainless steel versions
  The super stainless steel version EN 1.4539 (AISI 904 L) with silicon carbide-based (SiC/SiC) mechanical shaft sealing system and FKM rubber parts allow for its application in seawater and slightly contaminated environment that might contain hydrocarbons.
- Worldwide usage
  With different voltage and frequency combinations, the product range is available worldwide.
- Highly reliable thrust bearing
  Fitted with sturdy Michell thrust bearing, the motors offer highly reliable operation.
- Monitoring of motor temperature
  To achieve maximum protection of the motor against burnout, the asynchronous motor is available with a built-in Tempcon temperature sensor with power-line communication. In combination with motor protection (MP204), the sensor offers optimal protection of the motor.
  This type of temperature monitoring can only be used for asynchronous motors, it is not available for use with a VFD.
- Additional monitoring of motor temperature
  As over-temperature protection, a Pt100 or Pt1000 sensor can be connected to the MS6000 motor to monitor the temperature. This solution is used in combination with frequency-controlled motors, including the MS6000P.

Applications

The Grundfos MS6000 and MS6000P submersible motors are designed for a wide range of applications such as the following:

- deep-well water supply
- irrigation
- groundwater regulation
- pressure boosting
- industrial-water transfer and similar applications
- fountains
- dewatering.

Application variants

The M6000 asynchronous submersible motor is available in a wide range of variants for different applications:

- MS6000T40
  This variant is for operation in normal groundwater with temperatures up to 40 °C. The elastomer is NBR.
- MS6000XT40
  This variant is for operation in normal groundwater with temperatures up to 40 °C. The motor is without Tempcon sensor. The elastomer is NBR.
- MS6000DT40
  This variant is for applications in normal groundwater where the contamination with glycol-based motor liquids is not permissible (for example in chip manufacturing). The motor comes pre-filled with demineralized water from the factory. The elastomer is NBR.
- MS6000WT40
  This variant is for applications where horizontal operation is common and turbine operation may occur. The motor has tungsten carbide/SiC bearings. The elastomer is NBR.
- MS6000QT40
  This variant is for operation in normal groundwater with abrasive particles and temperatures up to 40°C. The motor contains a SiC/SiC shaft seal with elastomers in NBR
- MS6000REST40
  This variant is for operation in aggressive liquids with abrasive particles. The elastomer is FKM.
- MS6000RESWT40
  This variant is for operation in aggressive liquids with abrasive particles in applications where horizontal operation is common and turbine operation may occur. The elastomer is FKM.
- MS6000RESWDT40
  This variant is for applications in aggressive liquids with abrasive particles that do not allow the risk of contamination with motor liquid based on glycol, and where horizontal operation is common (e.g. RO plants), the motor is factory-filled with demineralized water. The elastomer is FKM.

- MS6000QFT40

  This variant is for operation in normal groundwater with abrasive particles and temperatures up to 40 °C. The motor contains a SiC/SiC shaft seal and nitrile rubber (NBR) parts, therefore, it is approved for drinking water. Furthermore, it is mounted with an extension flange for the US market. The elastomer is NBR.

- MS6000QFXT40

  This variant is for operation in groundwater with temperatures up to 40 °C, and with abrasive particles, in applications where horizontal operation is common and turbine operation may occur. The motor contains a SiC/SiC shaft seal and nitrile rubber (NBR) elastomers, therefore, it is approved for drinking water. Furthermore, it is mounted with an extension flange for the US market. The motor is without a Tempcon sensor.

- MS6000T60

  This variant is for operation in normal groundwater with temperatures up to 60 °C. The elastomer is NBR.

- MS6000QFT60

  This variant is for operation in groundwater with abrasive particles and temperatures up to 60 °C, in applications where horizontal operation is common and turbine operation may occur. The motor contains a SiC/SiC shaft seal and nitrile rubber (NBR) elastomers, therefore, it is approved for drinking water. Furthermore, it is mounted with an extension flange for the US market.

- MS6000REST60

  This variant is for operation in aggressive liquids with abrasive particles and temperatures up to 60 °C. The elastomer is FKM.

- MS6000RESXT60

  This variant is for operation in aggressive liquids with abrasive particles and temperatures up to 60 °C. The motor is without Tempcon sensor. The elastomer is FKM.

- MS6000RESWT60

  This variant is for operation in aggressive liquids with abrasive particles and temperatures up to 60 °C, in applications where horizontal operation is common and turbine operation may occur. SiC/SiC shaft seal. The elastomer is FKM.

- MS6000EST60

  This variant is for operation in neutral liquids up to 60 °C with low content of hydrocarbons and dissolved gasses. The elastomer is FKM.

The MS6000P synchronous submersible motor is available in a wide range of variants for different applications:

- MS6000PQXT60

  This variant is for operation in groundwater with temperatures up to 60 °C, and with abrasive particles, in applications where horizontal operation is common and turbine operation may occur. The motor contains a SiC/SiC shaft seal and nitrile rubber (NBR) elastomers, therefore, it is approved for drinking water. The motor is without Tempcon sensor.

- MS6000PQXFT60

  This variant is for operation in groundwater with temperatures up to 60 °C, and with abrasive particles, in applications where horizontal operation is common and turbine operation may occur. The motor contains a SiC/SiC shaft seal and nitrile rubber (NBR) elastomers, therefore, it is approved for drinking water. Furthermore, it is mounted with an extension flange for the US market. The motor is without Tempcon sensor.

- MS6000PRESXT60

  This variant is for operation in aggressive liquids with temperatures up to 60 °C, and with abrasive particles. The motor contains a SiC/SiC shaft seal. The motor is without Tempcon sensor. The elastomer is FKM.

2. Identification

Type key

Example	MS6000	R	E	S	W	D	F	X	T40	3 x 400/50 460/60	SD	18.5 kW
Pos.	1	2	3	4	5	6	7	8	9	10	11	12

Pos.	Description		
1	Motor type		
	- = MS6000 asynchronous motor		
	P = MS6000P synchronous motor		
2	Material type		
	- = EN 1.4301		
	R = EN 1.4539		
3	Elastomers		
	- = NBR		
	E = FKM		
4	Shaft seal		
	- = Ceramic/carbon with NBR	BXPFF	
	S = SiC/SiC with FKM	Q1Q1VFF	
	Q = SiC/SiC with NBR	Q1Q1PFF	
5	Radial bearings		
	- = Carbon graphite/Stainless steel		
	W = SIC/Tungsten carbide		
6	Motor liquid		
	- = SML-3		
	D = Demineralized water		
	H = Glycol 60 vol % HTF		
7	Flange extension		
	- = Without		
	F = With		
8	Tempcon		
	- = With		
	X = Without		
9	Max. liquid temperature		
	T40 = 40 °C		
	T60 = 60 °C		
10	Voltage		Approval options
	3 × 340-380/50 440/60	= 3 x 340-380 V, 50 Hz 3 x 440 V, 60 Hz	CE
	3 x 200/50 200-220/60	= 3 x 200 V, 50 Hz 3 x 200-220 V, 60 Hz	CE
	3 x 220-230/50	= 3 x 220-230 V, 50 Hz	CE
	3 x 400/50 460/60	= 3 x 380-400-415 V, 50 Hz 3 x 440-460-480 V, 60 Hz	CE or cCSAus
	3 x 400/50 400-440/60	= 3 x 400 V, 50 Hz 3 x 400-440 V, 60 Hz	CE
	3 x 690/50	= 3 x 690 V, 50 Hz	CE
	3 x 208-220-230/60	= 3 x 208-220-230 V, 60 Hz	CE or cCSAus
	3 x 380-400/60	= 3 x 380-400 V 60 Hz	CE
	3 x 500/50 575/60	= 3 x 500-525 V, 50 Hz 3 x 575 V, 60 Hz	CE or cCSAus
	3 x 690/60	= 3 x 690 V, 60 Hz	CE
	3 x 350/100 410/120	= 3 x 350 V, 100 Hz 3 x 410 V, 120 Hz	CE or cCSAus
11	Method of starting		
	- = DOL		
	SD = SD		

Pos.	Description	
12	Motor power	
	3.7 kW	5.0 hp
	5.5 kW	7.5 hp
	7.5 kW	10 hp
	9.2 kW	12 hp
	11 kW	15 hp
	13 kW	17 hp
	15 kW	20 hp
	18.5 kW	25 hp
	22 kW	30 hp
	26 kW	35 hp
	30 kW	40 hp
	37 kW	50 hp
	45 kW	60 hp

The type key cannot be used for ordering as not all combinations are possible.

3. Operating conditions

Pumped liquid

The MS6000(P) motors are produced with different materials to enable their use in various liquids.

- The standard material version (EN 1.4301/ss 316) is intended for use in freshwater without any appreciative chloride content. The R material version (EN 1.4539/ss 904L) is recommended for use in water with chloride content, for example, seawater, or in aggressive liquids, for example, mine applications.
- Elastomers made of NBR are intended for drinking water applications, while FKM elastomers are intended for operation in neutral liquids with hydrocarbon content and dissolved gasses.
- Shaft seal with HM/ceramic faces is for use in water without abrasive particles. In water with abrasive particles, such as sand, or aggressive liquids, the Sic/Sic shaft seal is recommended.

The motors are designed for use in applications with a maximum permissible abrasive content of 200 ppm in the pumped liquid.

For special applications, make an analysis of the liquid and contact Grundfos.

Chloride containing water

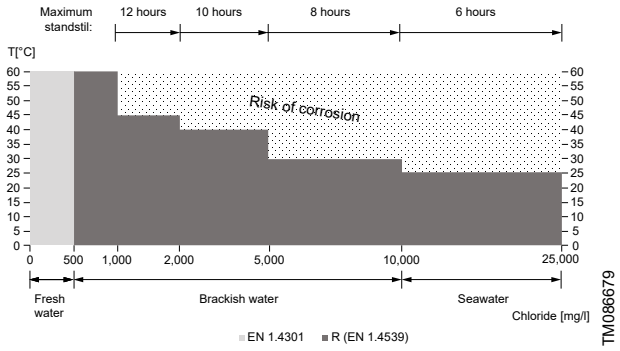
When immersed in chloride-containing water, stainless steel can be damaged by crevice or pitting corrosion.

The likelihood of corrosion depends on the following factors:

- material version (standard, R)
- chloride concentration in the water
- temperature
- oxygen concentration
- presence of biological activity
- velocity of the water around the motor
- pH value
- presence of disinfectant, such as chlorine, sulphuric acid, for example, in mining applications, and chemicals.

The increase in chloride concentration and/or temperature is unfavorable to stainless steel. Additionally, standstill time and biological activity increase the risk of corrosion. At chloride concentrations above 1000 mg/l, longer standstill periods must be avoided. All these factors must be considered when selecting the right material version and assessing the cathodic protection requirement.

The following diagram shows the allowable ranges of each material version for water with pH above 6.5.



Corrosion resistance diagram at pH above 6.5

Pos.	Description
T [°C]	Pumped water temperature in Celsius
Chloride [mg/l]	Chloride concentration in mg/l

Cathodic protection must be used when there is a risk of corrosion, that is, in standstill periods or temperatures higher than those allowed in the table above. Grundfos offers sacrificial zinc anodes to bring cathodic protection, see section on *Accessories*. Cathodic protection is not recommended in liquids with a pH value lower than 6 or above 9.

If aggressive liquids are pumped, a flow sleeve may be required to ensure sufficient cooling, that is, flow and temperature, around the motor, since corrosion is doubled for every 10 °C rise in temperature.

To splice motor cables and drop cables, use the type KM cable termination kits in seawater applications.

Ambient pressure

Maximum ambient pressure: 60 bar ~ 6.0 MPa.

Grundfos does not recommend that you operate the motor in a vacuum. If it cannot be avoided, contact Grundfos.

Cooling

The cooling of the motor depends on the temperature and the flow velocity of the pumped liquid passing the motor. It is important to maintain the maximum temperature of the pumped liquid and its minimum velocity passing the motor to ensure sufficient cooling of the motor. See the table below.

Motor	Maximum temperature	Minimum flow velocity	Minimum absolute pressure
MS6000 (T40 versions)	40 °C (104 °F)	0.15 m/s (0.50 ft/s)	1 bar (14.5 psi)
MS6000 (T60 versions)	60 °C (140 °F)	1 m/s (3.30 ft/s)	1 bar (14.5 psi)
	60 °C (140 °F)	0.15 m/s (0.50 ft/s)	2 bar [1] (29 psi)
MS6000P	60 °C (140 °F)	0.15 m/s (0.50 ft/s)	1 bar (14.5 psi)

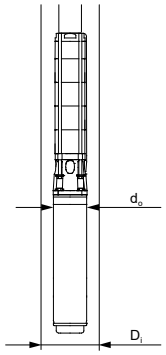
1) It is equivalent to a water column of 10 meters above the motor.

Calculation of the flow velocity

$$V = \frac{Q \times 353}{D_i^2 - d_o^2} \left[m/s \right]$$

Legend

v	flow velocity passing the motor [m/s]
Q	pump rated flow [m^3/h]
D_i	internal borehole diameter [mm]
d_o	outer motor diameter [mm]



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Diameter of motor and borehole

Recommendations for optimal cooling

It is recommended that you install the motor above the well screen to achieve proper motor cooling.

If the stated liquid velocity cannot be achieved, a flow sleeve must be installed.

If there is a risk of sediment buildup, such as sand, around the motor, a flow sleeve should be used to ensure proper cooling of the motor. If a flow sleeve is used, the motor can be placed in the well screen.

Thrust bearing

The axial thrust load capacity is related to the motor configuration and size. The following table shows the standard configurations. Variants with oversized thrust load capacities for special applications are available upon request. Contact Grundfos.

Model	Phase	Temp. version	Rated power		Axial thrust load capacity
			Min.	Max.	
			[kW (hp)]	[kW (hp)]	[N]
M6000	3 ph	T40	3.7 (5.0)	7.5 (10)	7500 [2]
			9.2 (12)	30 (40)	27000
		T60	3.7 (5.0)	7.5 (10)	27000
			9.2 (12)	22 (30)	40000
M6000P	3 ph	T60	4.0 (5.0)	7.5 (10)	7500 [3]
			9.2 (12)	30 (40)	27000
			37 (50)	45 (60)	40000

2) cCSAus-approved motors are delivered with 27000 N thrust bearing.

3) Motors with extension flange for the US market are delivered with 27000 N thrust bearing.

Frequency of starts and stops

The motor is designed for continuous operation, S1 duty.

Minimum number of starts: 1 per year is recommended. Alternatively the shaft can be turned by hand.

Maximum number of starts:

Motor type	Number of starts
MS6000	Maximum 30 per hour Maximum 300 per day
MS6000P	Maximum 120 per hour Maximum 360 per day

The maximum number of starts applies only to the motor. The maximum number of starts may be limited by the pump design.

Output power

The rated power (P2), service factor (SF), and SF current (Max. SF C.) are stamped on the nameplate for a respective supply, such as rated voltage and frequency. The SF power is the maximum power output, and equals the rated power times the SF.

The Grundfos submersible motors are designed to run continuously (S1 Duty) at maximum SF current with SF power, as long as cooling and supply requirements are met.

Related information

Supply requirements

Frequency converter operation

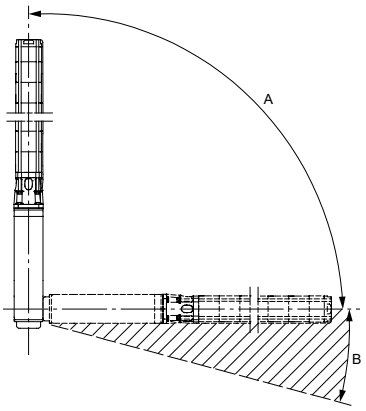
Motor cooling

4. Mechanical installation

The motor can be installed either horizontally or vertically, but must be fully submerged in the pumped liquid during operation to ensure sufficient cooling.

Horizontal installation

If the motor is installed horizontally, the shaft end must not fall below the horizontal level, and the use of a flow sleeve is recommended.



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Positional requirements

A =	Allowed
B =	Not allowed

Vertical installation

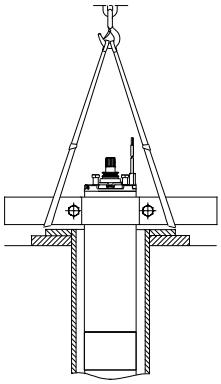
Installation depth below water level

Maximum installation depth allowed: 600 m.

Fitting the motor to the pump

Follow the steps below to fit the motor to the pump:

1. Use pipe clamps when handling the motor.
2. Place the motor in vertical position at the wellhead seal, as illustrated in the below figure.



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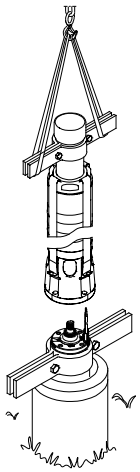
Motor in vertical position

3. Lift the pump part with pipe clamps fitted to the extension pipe, as illustrated in the figure.



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Lifting the pump into position

4. Place the pump part on top of the motor and tighten the screws.
5. Fit the cable along the chamber stack, and mount the cable guard.
6. Make sure that the coupling between the pump and motor engages properly.

Lowering the motor

1. Before lowering the motor, check the borehole with an inside calliper to ensure unobstructed passage.
2. Carefully lower the motor into the borehole so as not to damage the motor cable or the submersible drop cable.

Do not lower or lift the motor by the motor cable!

5. Electrical installation

Electrical installation must comply with the local legislation.

Supply requirements

In Direct-On-Line applications, the MS6000 asynchronous motor has the following requirements regarding the rated voltage stamped on the motor:

- voltage-range motors: + 6 %/- 10 %
- fixed-voltage motors: + 10 %/- 10 %.

The voltage is either calculated, or measured at the motor terminals. The tolerance allows for variations in the mains supply and losses in the cables.

There must be voltage symmetry in the supply network, that is, the voltage difference between the individual phases must be the same. When the motor is operating, there must be current symmetry, that is, the three phases must be evenly loaded.

The voltage and current unbalance between the phases must be within the following limits:

- maximum voltage unbalance: 2 %
- maximum current unbalance: 5 %.

In frequency converter applications, the supplied voltage at the motor terminals must not exceed the limits stated on the *Submersible motor limits* table in section *Frequency converter operation*. Additionally, the voltage at rated frequency and the voltage and current unbalances must be kept within the tolerances of the Direct-On-Line applications.

Related information

Output power

Determining direction of rotation

Once the motor is connected to the electricity supply, confirm that the direction of rotation is correct.

1. Start the motor for a short period and check the direction of rotation by watching the motor shaft.
2. Confirm that the direction of rotation corresponds to the demand of the pump.
3. Interchange two of the phase connections if the direction of rotation is wrong.

If the motor is fitted to a Grundfos SP or SPA submersible pump, the correct direction of rotation is counterclockwise as seen from the shaft end.

If the motor is started without being connected to a pump, the shaft end must be shielded.

Frequency converter operation

The MS6000 asynchronous motor can be used in frequency converter applications.

The MS6000P synchronous motor needs to be connected to a frequency converter able to handle IPM-type synchronous permanent-magnet motors.

Depending on the type, the frequency converter may cause increased acoustic noise from the motor and expose it to detrimental voltage peaks. This can be diminished by installing an output filter between the frequency converter and the motor.

Local and national requirements for safety, electromagnetic interference (EMI), and so on, must always be followed, including a demand for filtering due to, for example, electromagnetic compatibility or noise suppression.

Cables and other system components must be properly rated for frequency converter applications.

Overload protection

The motor must be protected against overload by adjusting the output current limit of the frequency converter either to the same value as the rated SF current on the motor nameplate or to a threshold based on the maximum actual current of the motor during operation.

Temperature monitoring

A Pt100 sensor can be installed to measure the motor temperature when it is driven by a frequency converter. The Pt100 signal can then be monitored directly by the frequency converter or via a PR 5714 relay.

The Tempcon, that is, the built-in temperature transmitter, cannot be used to monitor the temperature of a motor operated via a frequency converter. The converter signal would melt the fuse in the Tempcon and it cannot be replaced.

Frequency range

The rated frequency on the motor nameplate must not be exceeded.

The minimum permissible frequency for the MS6000 is 30 Hz, and for the MS6000P, it is 55 Hz.

The permissible frequency ranges are the following:

MS6000	30-50 Hz 30-60 Hz
MS6000P	55-100 Hz 55-120 Hz

In submersible pump installations, a reduction of the rated frequency often results in an increased generation of heat in the motor. Although the motor load is reduced with its frequency, the load reduction is very small as the major part of the power input is often consumed to overcome the static head. Moreover, at a reduced frequency, the flow passing the motor decreases, reducing cooling efficiency. Therefore, it is important never to decrease the frequency, thus the pump speed and the flow, below the permissible range. The motor must cut out if the pump stops pumping water.

See the table related to *Submersible motor limits*.

Ramp times

The start and stop ramp times to and from the minimum permissible frequency must be fast enough to allow the formation and maintenance of the lubricant film in the thrust bearing.

MS6000:

- start ramp from 0 to 30 Hz: maximum 3 seconds
- stop ramp from 30 to 0 Hz: maximum 3 seconds.

MS6000P:

- start ramp from 0 to 55 Hz: maximum 3 seconds
- stop ramp from 55to 0 Hz: maximum 3 seconds

Ramps between the minimum permissible frequency and the operation frequency can be set according to the application.

MS6000P setup

The Grundfos CUE is pre-programmed with the characteristics of the MS6000P and the Grundfos sine-wave filters delivered in the SPE systems. The user only needs to select the motor size on the start-up guide, no parameter programming is required.

The Grundfos RSI allows the setup of the motors through its start-up wizard and motor autotune function.

In case another frequency converter brand is used, the supplier manual must be followed to set up the motor. It is recommended to use the motor recognition function, if available, to set up the motor. The following parameters may be required in addition to the nameplate data:

MS6000P characteristics

Power range [kW]	4.0 - 7.5	9.2 - 18.5	22-30	37-45
Power range [hp]	5.0 - 10.0	12-25	30-40	50-60
PM back EMF at 1000 rpms [V] [4]	89	87	90	92
Stator resistance (Rs) [ohm] [5]	0.5384	0.228	0.1553	0.0930
d-axis inductance (Ld) [mH] [5]	11.0	4.6	3.4	2.1
q-axis inductance (Lq) [mH] [5]	26.4	11.7	8.0	5.5
Minimum frequency [Hz]	55			
Minimum speed [rpm]	1650			
Number of poles	4			
Permanent magnet motor type	Interior permanent magnet (IPM)			

4) Line-to-line

5) Line-to-common

Output filter

The frequency converter introduces electromagnetic noise and voltage peaks to the voltage signal. Voltage peaks are amplified in the cable between the frequency converter and the motor, and can damage the insulation system of the motor. The voltage peak levels at motor terminals depend on many factors:

- voltage supply to the frequency converter
- cable length
- switching frequency
- frequency converter type.

At motor terminals, voltage peaks (Upeak) and the voltage rise time (dU/dt) must not exceed the values shown in the table *Submersible motor limits*. To ensure this, an output filter between the frequency converter and the motor may be required. If the frequency converter has a voltage boost function, the use of an output filter is always needed.

Grundfos always recommends the use of sine-wave filters, that also reduce electromagnetic noise.

Submersible motor limits

	Voltage limits at motor terminals [6]	
Motor type	Max. dU/dt [V/us]	Max. Upeak (Line-Line) [V]
MS6000	6000	850
MS6000P	6000	1500

6) They must be ensured regardless of the frequency converter brand/model.

The technology of the Grundfos CUE and the 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 length up to 500 m. For installations requiring longer cables, please contact Grundfos. For more information, see the table below.

CUE/RSI supply and cable length limits

	Operating with CUE/RSI					
	Without filter			With Sine-wave filter		
Motor [7] type	Max. supply to CUE/RSI		Max. unscreened cable length	Max. supply to CUE/RSI		Max. unscreened cable length
	[Vac [8]]	[Vdc [9]]	[m]	[Vac [8]]	[Vdc [9]]	[m]
MS6000	240	400	100	575/500 [10]	800	500
MS6000P	460	620	300	575/500 [10]	800	500

7) Motors operating within their temperature rating

8) Single-phase or three-phase AC supply (rms Voltage)

9) RSI with renewable energy DC supply

10) 575 V for the CUE and 500 V for the RSI

The robust insulation of the MS6000P allows it to be used without a sine-wave filter and a frequency converter of any brand if all the requirements in the table *Requirements to operate the MS6000P without a sine-wave filter* are fulfilled. The SPE systems supplied by Grundfos, that is, SP pump withMS6000P and a CUE, meet the VFD and motor input requirements, therefore a sine-wave filter is not required when the *Application and Grid requirements* are met.

Requirements to operate the MS6000P without a sine-wave filter

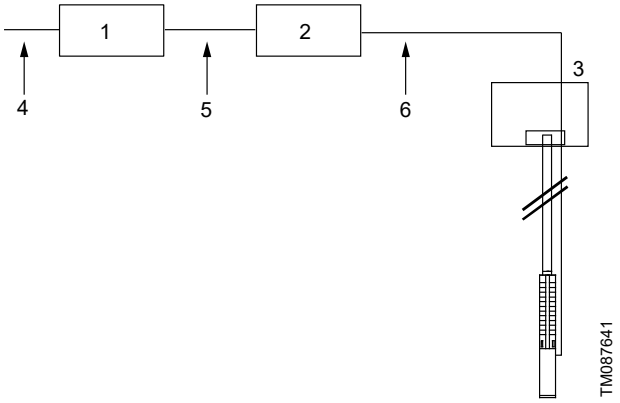
	Value	Unit	Grundfos SPE systems
Application requirements			
Max. media temperature	60/140	[°C/°F]	Must be met
Max. cable length	300/1000	[m/ft]	Must be met
Grid requirements			
Max. line-line voltage	460	[V RMS]	Must be met
Phases	3	[-]	Must be met
VFD requirements			
Max. DC voltage	620	[V_{DC}]	✓
Max. 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]	✓

Cables configuration

When a frequency converter is installed in connection with SP pumps, there are two types of installation:

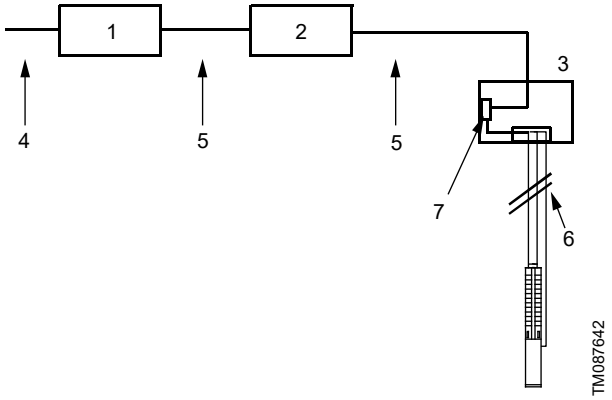
- installation in EMC-insensitive sites.
- installation in EMC-sensitive sites.

The two installation types differ in the use of screened cable. Screened cables are required in those parts of the installation where the surroundings must be protected against EMI. Drop cables inside the borehole are always unscreened. The screened cable between the frequency converter and the filter must be short.



Example of installation in EMC-insensitive sites

Pos.	
1	Frequency converter
2	Sine-wave filter
3	Borehole / well head
4	Mains cable, unscreened
5	Screened cable
6	Drop cable, unscreened



Example of installation in EMC-sensitive sites

Pos.	Description
1	Frequency converter
2	Sine-wave filter
3	Borehole / well head
4	Mains cable, unscreened
5	Screened cable
6	Drop cable, unscreened
7	Connection box

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

Related information

Output power

Accessories

Grundfos offering, CUE and Sine-wave easy selection for the MS6000P

Soft starter for the MS6000 asynchronous motor

Grundfos only recommends soft starters that control the voltage on all three phases and are provided with a bypass contactor.

Soft starters with bypass contactor only operate during ramp-up and ramp-down. This reduces both the load on the soft starter and the energy consumption in comparison with operation without bypass contactor.

The soft starter must not be used in connection with operation via a generator.

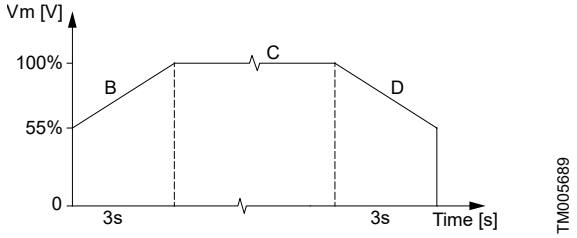
The starting voltage is minimum 55 % of the value stated on the motor nameplate.

If a high locked-rotor torque is required or if the electricity supply is not optimal, the starting voltage should be higher.

Ramp times:

- ramp-up time (until the voltage stated on the nameplate is reached): 3 seconds.
- ramp-down time: 3 seconds.

If the ramp-up and ramp-down times are followed, you avoid unnecessary heating of the motor.



Soft starter

Pos.	Description
Vm [V]	Motor rated voltage in volts
B	Start ramp
C	Operation
D	Stop ramp
Time [s]	Time in seconds

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

6. Construction

Material specification

Pos.	Description		MS6000XT40 MS6000XT60 MS6000T40 MS6000T60 MS6000WT40 MS6000DT40	MS6000QT40 MS6000QFT40 MS6000QFT60 MS6000QFXT40 MS6000PQXT60 MS6000PQFXT60	MS6000EST60	MS6000RESXT40 MS6000RESXT60 MS6000REST40 MS6000REST60 MS6000RESWT40 MS6000RESWT60 MS6000RESWDT40 MS6000RESWXT40 MS6000RESWXT60 MS6000PRESXT60
27a	Spacer for sand shield [11]		SS 316	SS 316	-	-
25a	Flange extension [11]		SS 304 H	SS 304 H	-	-
21	Washer		EN 1.4162	EN 1.4162	-	-
32	Shaft seal housing		EN 1.4308	EN 1.4308	EN 1.4308	EN 1.4517
24	O-ring		NBR	NBR	FKM	FKM
32a	Lip seal		-	-	-	EN 1.4301 FKM
27	Sand shield		EN 1.4301	EN 1.4301	EN 1.4301	EN 1.4539
			NBR	NBR	FKM	FKM
22	Screw		A4	A4	A4	EN 1.4539
22a	Screw and washer		A4	A4	A4	EN 1.4539
			PA66	PA66	PA66	PA66
50	Screw		A4	A4	A4	EN 1.4539
33	Shaft seal stationary		Ceramic	SIC	SIC	SIC
34	Shaft seal rotating		Carbon	SIC	SIC	SIC
			NBR	NBR	FKM	FKM
28	Washer		EN 1.4301	EN 1.4301	EN 1.4301	EN 1.4301
1a	Valve		EN 1.4435	EN 1.4435	EN 1.4435	-
			NBR	NBR	-	-
5	Bearing DE	bearing retainer	EN 1.4308	EN 1.4308	EN 1.4308	EN 1.4308
		stationary bush	Carbon graphite	Carbon graphite	Carbon graphite	Carbon graphite
		stationary bush [12]	SiC	-	-	SiC
2a	Upthrust ring		PEEK+PTFE20	PEEK+PTFE20	PEEK+PTFE20	PEEK+PTFE20
2	Shaft with rotor	shaft extension	EN 1.4460	EN 1.4460	EN 1.4460	EN 1.4462
		bearing bush	EN 1.4057	EN 1.4057	EN 1.4057	EN 1.4057
		bearing bush [12]	Tungsten Carbide	-	-	Tungsten Carbide
		rotor cladding [13]	Hastelloy C4	Hastelloy C4	Hastelloy C4	Hastelloy C4
1	Stator housing		EN 1.4301	EN 1.4301	EN 1.4301	EN 1.4539
			EN 1.4408	EN 1.4408	EN 1.4408	EN 1.4584
4	Bearing NDE	bearing retainer	EN 1.0335	EN 1.0335	EN 1.0335	EN 1.0335
		stationary bush	Carbon graphite	Carbon graphite	Carbon graphite	Carbon graphite
		stationary bush [12]	SiC	-	-	SiC
7a	Clamping flange		EN 1.0976	EN 1.0976	EN 1.0976	EN 1.0976
41	Screw		Steel	Steel	Steel	Steel
42	Stop for bearing		EN 1.0330.3	EN 1.0330	EN 1.0330	EN 1.0330
6	Thrust bearing - rotating		EN 1.0715	EN 1.0715	EN 1.0715	GJS / EN 1.0715
			Ceramic	Ceramic	Ceramic	Ceramic
3	Thrust bearing - stationary		EN 1.0715	EN 1.0715	EN 1.0715	GJS / EN 1.0715
			Carbon	Carbon	Carbon	Carbon

Pos.	Description	MS6000XT40 MS6000XT60 MS6000T40 MS6000T60 MS6000WT40 MS6000DT40	MS6000QT40 MS6000QFT40 MS6000QFT60 MS6000QFXT40 MS6000PQXT60 MS6000PQFXT60	MS6000EST60	MS6000RESXT40 MS6000RESXT60 MS6000REST40 MS6000REST60 MS6000RESWT40 MS6000RESWT60 MS6000RESWDT40 MS6000RESWXT40 MS6000RESWXT60 MS6000PRESXT60
45	Shaft adjustment unit	EN 1.7139	EN 1.7139	EN 1.7139	GJS / EN 1.7139
49	Lock ring	EN 1.4301	EN 1.4301	EN 1.4301	EN 1.4301
7	Clamping flange	EN 1.0976	EN 1.0976	EN 1.0976	EN 1.0976
48	Screw and washer	A2 ≈ EN 1.4301	A2 ≈ EN 1.4301	A2 ≈ EN 1.4301	EN 1.4539
		PA66	PA66	PA66	PA66
46	Screw	Steel	Steel	Steel	Steel
12	Diaphragm	NBR	NBR	FKM	FKM
13	Bottom cover	EN 1.4301	EN 1.4301	EN 1.4301	EN 1.4539
	Motor liquid	SML-3	SML-3	SML-3	SML-3
	Motor liquid [14)]	Demineralized water	-	-	Demineralized water
220	Flat cable	EPR TML-B	EPR TML-B	EPR TML-B	EPR TML-B

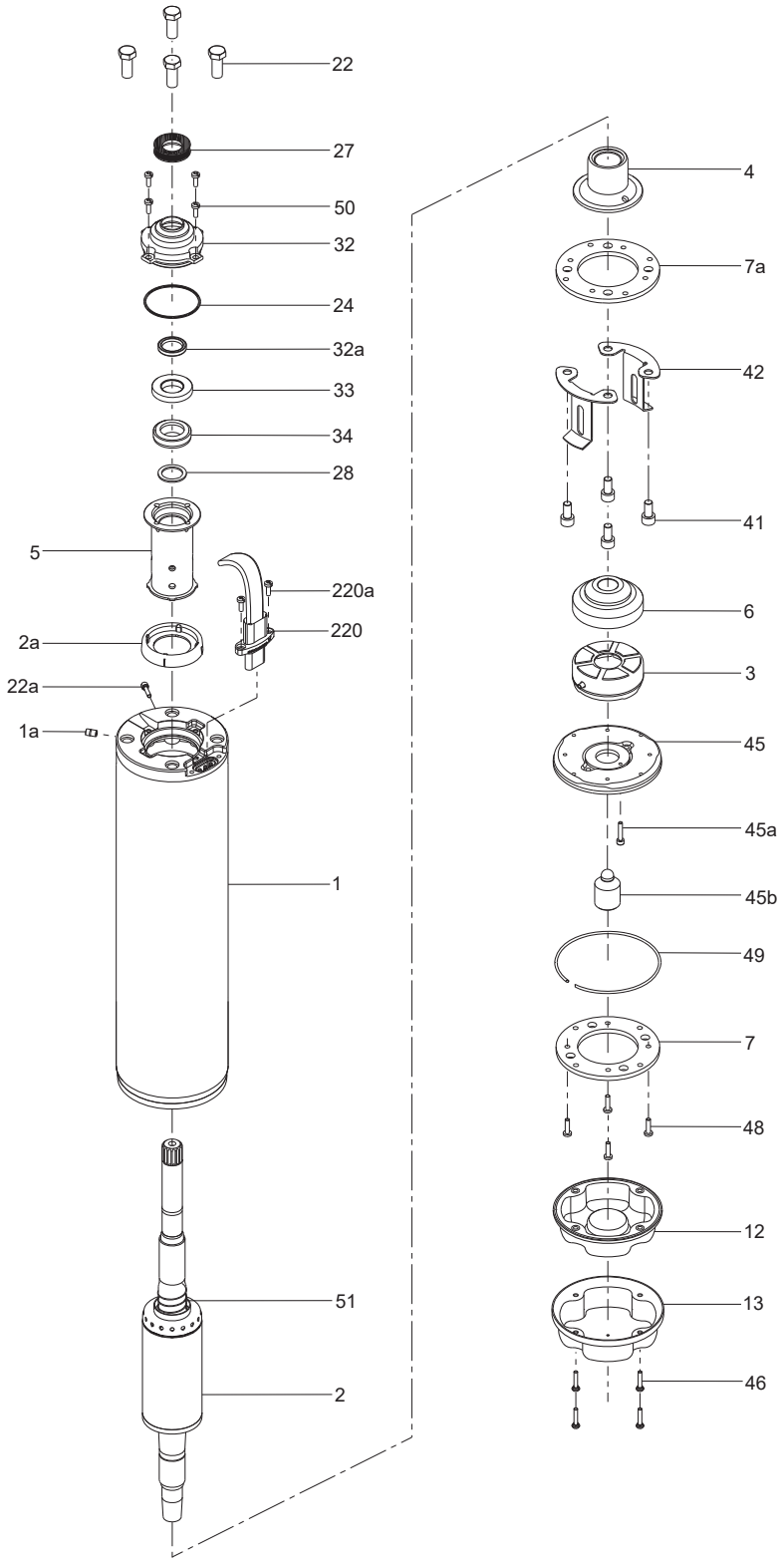
11) Motor with flange extension

12) Motor with hard radial bearing (tungsten carbide/SiC)

13) MS6000P synchronous motor only

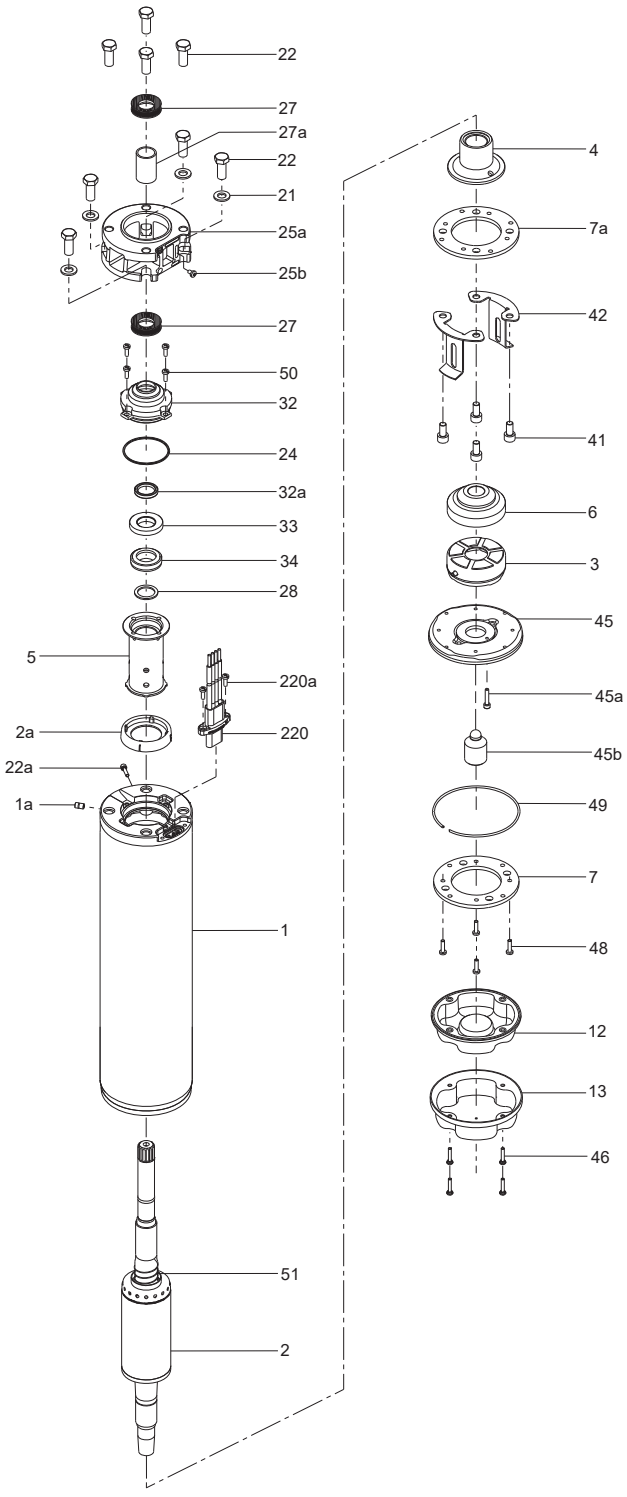
14) Motors factory-filled with demineralized water

Exploded drawing of MS6000



Exploded drawing of the MS6000 motor

Exploded drawing of MS6000 (with flange extension)



Exploded drawing of the MS6000

Description of the construction

The MS6000 motor is a 2-pole, asynchronous, squirrel-cage submersible motor.

The MS6000P motor is a 4-pole, synchronous, internal-permanent-magnet-type submersible motor.

Enclosure class: IP68 according to the IEC 60034-5.

Insulation class: F according to the IEC 60034-1.

The entire surface is stainless steel, which means that all external components have uniform corrosion resistance.

Cable connection

The motor is connected to the drop cable through a special motor cable approved for usage in drinking water.

The motor cable cannot be fitted or removed when the motor and the pump are assembled.

Motors for star-delta starting, and two-plug motor versions are fitted with two cables displaced by 90°.

- CE-marked motors are equipped with a 6 mm^2 or 10 mm^2 flat blue jacketed motor cable.
- cCSAus-marked motors are equipped with four single leads, type XLPE AWG8.

Motor D-end connection

The motor has standardised D-end according to the NEMA standard MG1-18.413, with four pieces of 1/2-20 UNF machine screws for mounting of the pump.

Shaft

The stainless steel, splined shaft end fulfills the ANSI B92.1, 1970, class 5. The motor has a 15-teeth module. The pressure angle is 30°.

Shaft seal

The MS6000 asynchronous motor is fitted with a standard mechanical shaft seal made of ceramic against carbon graphite for good dry-running capabilities, and optionally SiC/SiC faces for abrasive conditions.

The shaft seal is available for different applications in the following variants:

- ceramic against carbon graphite with NBR rubber parts — standard, approved for drinking water
- silicon carbide against silicon carbide with NBR rubber parts — approved for drinking water
- silicon carbide against silicon carbide with FKM rubber parts — suitable for high temperatures and liquids containing hydrocarbons.

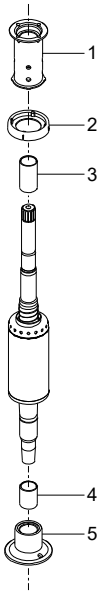
The MS6000P synchronous motor is fitted with a standard mechanical shaft seal of silicon carbide against silicon carbide with NBR rubber parts, which is approved for drinking water.

The MS6000P R-version is available with silicon carbide against silicon carbide with FKM rubber parts, suitable for high temperatures and liquids containing hydrocarbons.

Radial bearing

The shaft accommodates the rotating parts of the radial bearing both at the top and the bottom. The radial bearings are available in soft or hard versions:

- Soft radial bearing (standard): The rotating bearing bush made of stainless steel (EN 1.4057) is fixed to the shaft by interference fit. It runs against the static bush made of carbon graphite fixed to the bearing retainer by interference fit.
- Hard radial bearing (W): The rotating bearing bush is made of tungsten carbide sprayed to the shaft. It runs against the static bush made of silicon carbide fixed to the bearing retainer by interference fit. Hard radial bearings are recommended for use in horizontal booster applications.



Bottom and top radial bearings

1	Bearing retainer (DE) EN 1.4308
2	Upthrust ring
3	Bearing bush
4	Bearing bush
5	Bearing retainer (NDE) EN 1.0335

Related information

Upthrust ring

Upthrust ring

The upthrust ring prevents damage in case of upthrust. It is designed as a thrust ring limiting the upward axial movement of the motor shaft. In case of upward axial movement, the upthrust ring is stopped by the upper radial bearing retainer as seen in the figure in the topic on radial bearing.

Related information

Radial bearing

Rotor

The MS6000 asynchronous rotor is a squirrel-cage copper rotor interference-fitted on the shaft.

The MS6000P synchronous rotor is a rotor with internal permanent magnets interference-fitted on the shaft.

At both rotor types, the upper short-circuit ring is equipped with a small impeller, ensuring internal circulation of liquid in the rotor chamber, thus providing optimum lubrication.

Stator

The stator is hermetically encapsulated in stainless steel, and the windings are embedded in polymer compound. This results in high mechanical stability and optimal cooling, and eliminates the risk of short circuits in the windings caused by condensing water. The MS6000 has a 2-pole, while the MS6000P has a 4-pole winding.

Thrust bearing

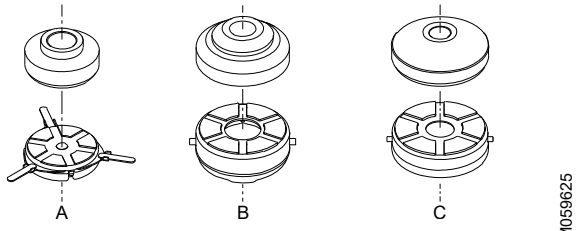
The thrust bearing is Michell type, a very simple and highly efficient bearing. It fulfills the requirements specified in the NEMA standards.

The thrust bearing consists of the following parts:

- There is a ceramic rotating part with precision-ground and polished sliding surface for optimum surface finish
- There is a stationary part that has six movable, specially ground carbon shoes for all sizes. It can be positioned so that all tolerances are absorbed, thus the bearing achieves optimal thrust capacity and minimum friction.

As the thrust bearing is made for bidirectional rotation, the motor can operate both clockwise and counterclockwise.

The thrust bearings are available in three sizes, depending on the pump load and the temperature of the pumped liquid. These bearings are dimensioned for axial load rated to 7.5, 27 and 40 kN, as seen on the figure below.



Thrust bearings

A	7.5 kN
B	27 kN
C	40 kN

Model	Phase	Temp. version	Rated power		Axial thrust load capacity
			Min.	Max.	
			[kW (hp)]	[kW (hp)]	[N]
M6000	3 ph	T40	3.7 (5.0)	7.5 (10)	7500 [15)]
			9.2 (12)	30 (40)	27000
		T60	3.7 (5.0)	7.5 (10)	27000
			9.2 (12)	22 (30)	40000
M6000P	3 ph	T60	4.0 (5.0)	7.5 (10)	7500 [16)]
			9.2 (12)	30 (40)	27000
			37 (50)	45 (60)	40000

15) cCSAus-approved motors are delivered with 27000 N thrust bearing.

16) Motors with extension flange for the US market are delivered with 27000 N thrust bearing.

The motor can always be upgraded with a larger thrust bearing, as stated in the table above, but it must not be downgraded with a smaller thrust bearing.

Diaphragm

The rubber diaphragm fitted between the stator and the motor end shield is dimensioned to equalize volume variations caused by the temperature rise resulting from intermittent operation.

Motor liquid

The motor is factory-filled with the Grundfos SML-3 motor liquid. The SML-3 is based on monopropylene glycol, contains anti-corrosive and lubricating additives, and is frost-proof down to -20 °C.

Motor liquid with a high glycol content (60 % HTF) is available for motors that are stored or operated at lower temperatures (down to -55 °C).

Mixtures with more than 60 % of glycol content are not recommended.

If the motor is entirely drained of SML-3 liquid, for instance, in connection with service, it must always be refilled with SML-3. When topping up with small amounts of liquid, demineralized or clean water may be used.

If motor liquid with monopropylene glycol base is not allowed for special applications, the motor may be factory-filled with demineralized water upon request. A motor filled with demineralized water must be frost-protected when stored or transported in freezing temperatures. The motor must not be stored without being filled with liquid.

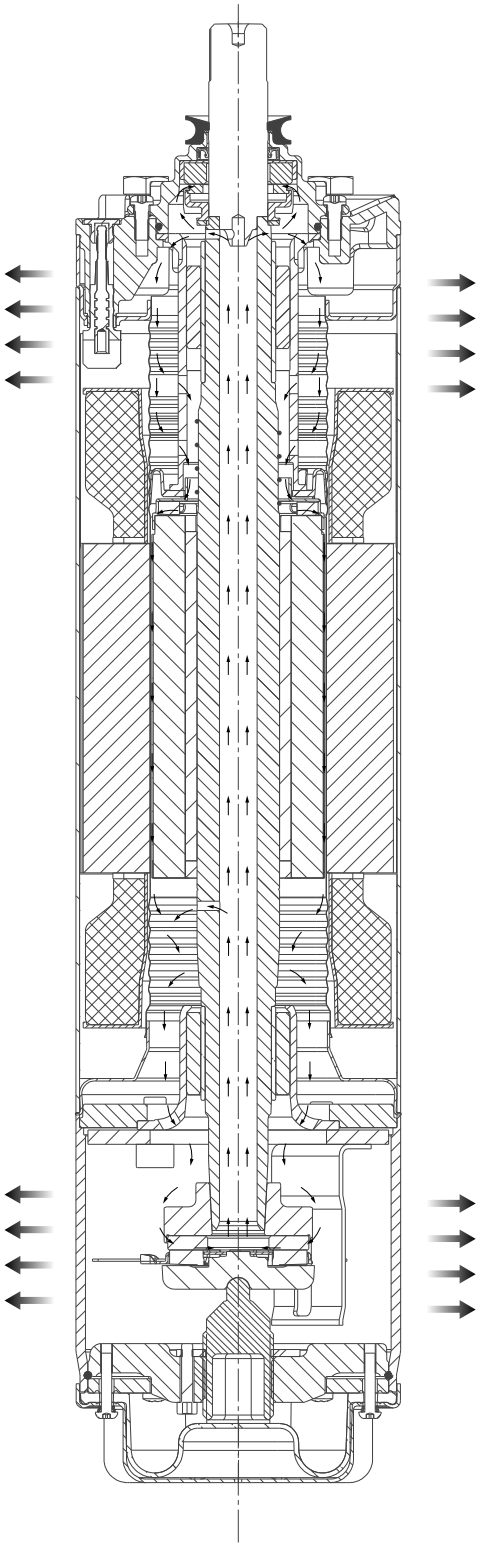
The table below lists the freezing points according to the percentage of monopropylene glycol (MPG) content of the motor liquid.

	Glycol content in the motor liquid	Freezing point
SML-3	36.5 % volume	-20 °C
High glycol (60% HTF)	57.6 % volume	-55 °C

Motor cooling

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

The temperature of the pumped liquid and its flow velocity passing the motor are essential to the lifespan of the motor. See the requirements in the topic on cooling requirements.



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Liquid circulation inside the motor

Related information

Output power

7. Technical data

Dimensional drawings

Dimensional drawing of the MS6000 and the MS6000P

A	1/2-20UNF
B	Spline 15x16/32 ANSI B92.

MS6000

Motor power, P_2 [kW]	Length [mm]		Weight [kg]		Shipping volume [m^3]	
	T40	T60	T40	T60	T40	T60
5.5	547	607	34.0	43.0	0.012	0.013
7.5	577	637	37.0	46.0	0.013	0.014
9.2	607	667	43.0	49.0	0.013	0.015
11	637	702	46.0	53.0	0.014	0.015
13	667	757	49.0	57.5	0.015	0.017
15	702	817	53.0	64.5	0.015	0.017
18.5	757	877	57.5	70.5	0.017	0.018
22	817	947	64.5	78.0	0.017	0.020
26	877	-	70.5	-	0.018	-
30	947	-	78.0	-	0.020	-

MS6000P

Motor power, P_2 [kW]	Length [mm]	Weight [kg]	Shipping volume [m^3]
	T60		
4	547	32.9	0.012
5.5			
7.5			
9.2	667	46.3	0.015
11			
13			
15			
18.5			
22	817	61.3	0.017
26			
30			
37	947	76.2	0.020
45			

Dimensional drawing of the MS6000 and the MS6000P with flange extension

A =	1/2-20UNF
B =	Spline 15x16/32 ANSI B92.

MS6000 three-phase

Motor power, P_2	Length [mm]		Weight [kg]		Shipping volume [m^3]	
[hp]	T40	T60	T40	T60	T40	T60
5	597	627	36.5	39.5	0.013	0.014
7.5	597	687	36.5	48.5	0.013	0.015
10	627	752	39.5	55.5	0.014	0.015
15	687	807	48.5	60.0	0.015	0.017
20	752	867	55.5	67.0	0.015	0.017
25	807	997	60.0	80.5	0.017	0.020
30	867	-	67.0	-	0.017	-
40	997	-	80.5	-	0.020	-

MS6000 single-phase

Motor power, P_2	Length [mm]	Weight [kg]	Shipping volume [m^3]
[hp]	T40		
5	627	39.5	0.014
7.5	687	48.5	0.015
10	752	55.5	0.015
15	807	60.0	0.017

MS6000P

Motor power, P_2	Length [mm]	Weight [kg]	Shipping volume [m^3]
[hp]	T60		
5	597	37.0	0.013
7.5			
10			
12.5	717	49.0	0.014
15			
17			
20			
25			
30	867	64.0	0.017
35			
40			
50	997	76.2	0.020

Motor cables

The MS6000 asynchronous motors are available with four types of motor cables, depending on motor size and approval marking.

Cable type	Designation
4 G 6 mm^2 (jacketed cable)	6
4 G 10 mm^2 (jacketed cable)	10
4 x 1 G 8 AWG single XLPE	8
3 x 1 G 8 AWG single XLPE (Booster applications)	

Motor		50 Hz	3 x 220-230 V		-		3 x 340-380 V		-		3 x 380-400-415 V		3 x 500-525 V	
		60 Hz	-		3 x 208-220-230 V		3 x 440 V		3 x 380-400 V		3 x 440-460-480 V		3 x 575 V	
		Approval	CE		CE		CE		CE		CE		CE	
kW	hp		DOL	SD	DOL	SD	DOL	SD	DOL	SD	DOL	SD	DOL	SD
5.5	7.5		6	6	6	6	6	-	6	6	6	6	6	-
7.5	10		6	6	10	6	6	-	6	6	6	6	6	-
9.2	12		10	6	10	6	6	-	6	6	6	6	6	-
11	15		10	6	10	6	6	-	6	6	6	6	6	-
13	17		10	6	10	10	6	-	6	6	6	6	6	-
15	20		10	6	10	10	10	-	10	6	6	6	6	-
18.5	25		10	10	10	10	10	-	10	6	10	6	6	-
22	30		10	10	10	10	10	-	10	6	10	6	10	-
26	35		-	10	-	10	10	-	10	10	10	6	10	-
30	40		-	10	-	10	10	-	10	10	10	10	10	-

Motor		50 Hz	3 x 200 V		3 x 400 V		-		3 x 380-400-415 V		3 x 500-525 V	
		60 Hz	3 x 200-220 V		3 x 400-440 V		3 x 208-220-230 V		3 x 440-460-480 V		3 x 575 V	
		Approval	CE		CE		cCSAus		cCSAus		cCSAus	
kW	hp		DOL	SD	DOL	SD	DOL	SD	DOL	SD	DOL	SD
5.5	7.5		6	-	6	-	8	-	8	-	8	-
7.5	10		6	-	6	-	8	-	8	-	8	-
9.2	12		10	-	6	-	-	-	-	-	-	-
11	15		-	6	-	6	8	-	8	-	8	-
13	17		-	6	-	6	-	-	-	-	-	-
15	20		-	10	-	6	8	-	8	-	8	-
18.5	25		-	10	-	6	8	-	8	-	8	-
22	30		-	10	-	6	8	-	8	-	8	-
26	35		-	-	-	-	-	-	-	-	-	-
30	40		-	-	-	-	-	-	8	-	8	-

The MS6000P synchronous motors are available with four types of motor cables, depending on motor size and approval marking.

Cable type	Designation
4 G 6 mm^2 (jacketed cable)	6
4 G 10 mm^2 (jacketed cable)	10
4 x 1 G 8 AWG single XLPE	8
3 x 1 G 8 AWG single XLPE (Booster applications)	

Motor power, P_2	**3 x 350 V 3000RPM (100 Hz)**	
[kW]	**Designation**	**Number of cables**
4	6	1
5.5		
7.5		
9.2		
11		
13		
15		
18.5		
22	10	1
26		
30		
37	10	2 [17)]
45		

17) The MS6000P motors of 37 and 45 kW are supplied with parallel motor cabling (DOL motor with two motor cables). Grundfos recommends to splice each motor cable to an individual drop cable using a Grundfos KM connection kit. At the borehole head, the two drop cables can be joined in a connection box.

8. Electrical data

Overview

The MS6000 asynchronous motor

Voltage code	Supply voltage	Method of starting	Service factor (60 Hz)	Approvals	Comment	Page
08	3 x 340-380 V, 50 Hz	DOL	-	CE	Low voltage	27, 28
	3 x 440 V, 60 Hz		1.15			35
09	3 x 200 V, 50 Hz	DOL	1.00	CE	Japan	30
	3 x 200-220 V, 60 Hz					38, 39
10	3 x 220-230 V, 50 Hz	DOL	-	CE		27
19	3 x 380-400-415 V, 50 Hz	DOL	-	CE		28, 29, 30
	3 x 440-460-480 V, 60 Hz		1.15			36, 37, 40, 41
35	3 x 380-400-415 V, 50 Hz	DOL	-	cCSAus		28, 29, 30
	3 x 440-460-480 V, 60 Hz		1.15			36, 37
60	3 x 220-230 V, 50 Hz	SD	-	CE		27
63	3 x 200 V, 50 Hz 3 x 200-220 V, 60 Hz	SD	1.00	CE	Japan	30 38, 39
64	3 x 400 V, 50 Hz 3 x 400-440 V, 60 Hz	DOL	1.00	CE	Japan	31 39, 40
	3 x 400 V, 50 Hz 3 x 400-440 V, 60 Hz	SD	1.00		Japan	31 39, 40
69	3 x 380-400-415 V, 50 Hz	SD	-	CE		28, 29, 30
	3 x 440-460-480 V, 60 Hz		1.15			36, 37, 40, 41
28	3 x 208-220-230 V, 60 Hz	DOL	1.15	CE		32, 33
30	3 x 208-220-230 V, 60 Hz	DOL	1.15	cCSAus		32, 33
33	3 x 380-400 V, 60 Hz	DOL	1.15	CE		34
18	3 x 500-525 V, 50 Hz	DOL	-	CE		29, 31
	3 x 575 V, 60 Hz		1.15			38, 42
39	3 x 500-525 V, 50 Hz	DOL	-	cCSAus		29
	3 x 575 V, 60 Hz		1.15			38
80	3 x 208-220-230 V, 60 Hz	SD	1.15	CE		32, 33
83	3 x 380-400 V, 60 Hz	SD	1.15	CE		34

The MS6000P synchronous motor

Voltage code	Supply voltage	Service factor (60 Hz)	Approvals	Comment	Page
20	3 x 350 V, 100 Hz, 3 x 410 V, 120 Hz	1.15	CE	Synchronous	43
37	3 x 350 V, 100 Hz, 3 x 410 V, 120 Hz	1.15	cCSAus	Synchronous	43

Voltage code 10, 60

3 x 220 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	24.4	80.3	79.9	76.4	0.78	0.70	0.57	2880	18.2	510	170	280
7.5	31.0	81.0	81.6	79.3	0.82	0.77	0.65	2870	25.0	500	160	250
9.2	38.5	81.1	81.4	78.8	0.81	0.74	0.61	2880	30.5	530	180	270
11	46.0	82.2	82.4	80.0	0.80	0.73	0.60	2880	36.5	530	180	290
13	52.5	82.3	83.2	81.5	0.83	0.78	0.67	2870	43.5	530	160	270
15	59.5	82.6	83.6	82.2	0.84	0.79	0.68	2860	50.0	520	150	260
18.5	74.0	83.2	84.0	82.4	0.83	0.78	0.66	2870	61.5	540	160	270
22	86.5	83.4	84.4	83.0	0.84	0.79	0.68	2870	73.0	540	160	260
26	100	83.4	84.6	83.4	0.85	0.81	0.70	2870	86.5	530	160	260
30	116	83.9	85.0	83.8	0.85	0.81	0.71	2870	100.0	520	160	270

3 x 230 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	24.8	80.0	78.8	74.4	0.73	0.64	0.51	2900	18.2	530	180	310
7.5	31.0	81.2	81.1	78.0	0.79	0.71	0.58	2880	25.0	530	180	280
9.2	39.0	81.1	80.6	77.1	0.77	0.68	0.55	2890	30.5	550	200	300
11	46.5	82.2	81.7	78.3	0.76	0.67	0.54	2890	36.5	560	200	320
13	52.0	82.6	82.7	80.2	0.80	0.72	0.59	2880	43.5	560	180	300
15	59.0	83.0	83.3	81.0	0.81	0.74	0.61	2880	50.0	560	170	290
18.5	73.5	83.5	83.5	81.0	0.80	0.71	0.58	2890	61.5	570	180	300
22	85.5	83.8	84.0	81.8	0.81	0.73	0.60	2890	73.0	570	180	300
26	99.5	83.9	84.2	82.3	0.82	0.76	0.63	2880	86.5	560	180	290
30	114	84.3	84.6	82.7	0.82	0.76	0.64	2880	100.0	560	180	300

Voltage code 08

3 x 340 V, 50 Hz, T40, Undervoltage motors

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	15.0	80.2	80.9	78.6	0.82	0.77	0.66	2860	18.4	470	140	240
7.5	20.0	78.9	81.3	80.4	0.84	0.82	0.73	2840	25.5	430	130	210
9.2	24.4	78.9	81.5	80.9	0.85	0.82	0.75	2830	31.0	440	140	210
11	29.0	79.7	82.3	81.9	0.85	0.82	0.73	2830	37.0	430	130	220
13	33.5	81.0	83.2	82.5	0.85	0.82	0.73	2840	43.5	470	140	240
15	38.5	80.7	83.2	83.0	0.85	0.83	0.76	2830	50.5	450	130	220
18.5	47.0	81.8	83.9	83.4	0.86	0.82	0.74	2850	62.0	480	140	230
22	55.5	82.2	84.6	84.4	0.86	0.84	0.77	2840	74.0	470	140	220
26	66.5	80.2	83.7	84.5	0.87	0.86	0.81	2820	88.0	410	120	200
30	74.5	81.9	84.6	84.8	0.88	0.86	0.80	2840	100	430	130	220

3 x 380 V, 50 Hz, T40, Undervoltage motors

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	15.2	80.3	79.0	74.5	0.72	0.63	0.50	2900	18.4	530	190	310
7.5	18.6	81.1	81.0	77.9	0.79	0.72	0.59	2880	25.5	530	180	270
9.2	22.6	81.3	81.4	78.5	0.80	0.72	0.59	2880	31.0	540	180	280
11	27.0	82.1	82.2	79.7	0.80	0.72	0.59	2880	37.0	540	180	290
13	32.0	82.6	82.6	79.8	0.79	0.70	0.57	2880	43.5	570	190	320
15	36.0	82.9	83.2	80.8	0.81	0.73	0.61	2880	50.5	560	170	290
18.5	45.0	83.3	83.4	80.8	0.79	0.71	0.57	2890	62.0	570	180	300
22	51.5	84.2	84.5	82.4	0.81	0.74	0.61	2880	74.0	570	180	300
26	58.5	83.7	84.7	83.3	0.85	0.80	0.69	2870	88.0	530	160	260
30	68.0	84.2	84.7	82.9	0.83	0.77	0.65	2880	100	550	180	290

Voltage code 19, 35, 69

3 x 380 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	13.6	79.8	80.4	78.0	0.82	0.76	0.65	2870	18.4	470	140	240
7.5	17.8	80.1	81.6	80.1	0.84	0.80	0.70	2850	25.0	460	140	230
9.2	21.8	80.3	81.9	80.4	0.84	0.80	0.69	2850	31.0	480	150	230
11	26.0	81.1	82.7	81.7	0.84	0.80	0.70	2850	37.0	470	150	240
13	30.0	81.5	83.2	82.2	0.85	0.81	0.71	2850	43.5	490	150	250
15	34.5	81.9	83.5	82.4	0.85	0.81	0.71	2860	50.0	490	140	240
18.5	42.0	82.7	84.1	83.1	0.85	0.81	0.70	2860	61.5	510	150	240
22	49.5	82.2	84.4	84.1	0.86	0.83	0.75	2850	74.0	480	140	230
26	58.0	82.4	84.5	84.2	0.87	0.84	0.76	2850	87.0	480	140	230
30	66.5	82.5	84.7	84.5	0.87	0.84	0.77	2850	100	450	140	230

3 x 400 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	13.4	80.2	79.8	76.4	0.78	0.70	0.57	2880	18.4	510	160	270
7.5	17.2	81.1	81.4	78.9	0.82	0.75	0.63	2870	25.0	510	160	260
9.2	21.2	81.2	81.7	79.2	0.82	0.75	0.63	2870	31.0	520	170	270
11	25.0	82.1	82.7	80.7	0.82	0.76	0.64	2870	37.0	520	170	270
13	29.0	82.4	83.1	81.1	0.82	0.76	0.64	2870	43.5	540	170	280
15	33.5	82.7	83.3	81.3	0.82	0.76	0.64	2870	50.0	540	170	280
18.5	41.0	83.4	83.9	81.9	0.82	0.75	0.63	2880	61.5	560	170	280
22	47.5	83.5	84.6	83.3	0.84	0.80	0.69	2870	74.0	530	160	260
26	55.5	83.6	84.7	83.4	0.85	0.80	0.69	2870	87.0	530	160	260
30	64.0	83.7	84.7	83.7	0.85	0.81	0.69	2870	100	500	160	260

3 x 415 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	13.6	80.0	79.0	74.8	0.75	0.66	0.53	2890	18.4	520	180	300
7.5	17.2	81.2	80.9	77.7	0.79	0.70	0.57	2880	25.0	530	180	280
9.2	21.2	81.4	81.1	77.9	0.78	0.70	0.57	2880	31.0	550	190	290
11	24.8	82.3	82.3	79.6	0.79	0.71	0.57	2880	37.0	540	180	300
13	29.0	82.6	82.6	79.9	0.79	0.71	0.58	2880	43.5	560	180	310
15	33.5	82.9	82.8	80.1	0.79	0.71	0.58	2880	50.0	570	180	310
18.5	41.5	83.4	83.4	80.7	0.79	0.70	0.57	2890	61.5	580	190	310
22	46.5	83.9	84.3	82.4	0.82	0.76	0.63	2880	74.0	560	180	290
26	55.0	84.0	84.4	82.4	0.82	0.76	0.64	2880	87.0	560	180	290
30	63.0	84.0	84.4	82.7	0.82	0.76	0.64	2880	100	530	170	290

Voltage code 18, 39

3 x 500 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	10.6	80.2	79.9	76.6	0.79	0.71	0.58	2880	18.2	500	160	270
7.5	13.8	80.5	81.0	78.5	0.82	0.76	0.64	2870	25.0	500	160	250
9.2	16.8	81.1	81.5	79.1	0.82	0.75	0.63	2870	30.5	520	170	260
11	19.8	81.9	82.7	80.7	0.82	0.76	0.64	2870	36.5	510	160	270
13	23.6	82.4	82.9	80.7	0.82	0.75	0.62	2870	43.0	550	170	290
15	27.0	82.5	83.0	80.7	0.82	0.75	0.62	2880	50.0	550	170	280
18.5	33.0	82.8	83.3	81.1	0.82	0.75	0.63	2880	61.5	560	170	280
22	37.5	83.0	84.5	83.6	0.85	0.81	0.71	2860	73.5	520	150	250
26	44.0	83.4	84.7	83.6	0.85	0.81	0.70	2870	86.5	520	160	260
30	50.5	83.8	84.9	83.8	0.86	0.82	0.71	2870	100.0	520	160	260

3 x 525 V, 50 Hz, T40

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	10.8	79.9	78.8	74.5	0.73	0.65	0.52	2890	18.2	520	180	300
7.5	13.8	80.6	80.2	76.8	0.78	0.69	0.56	2880	25.0	530	180	280
9.2	17.0	81.1	80.7	77.3	0.77	0.69	0.55	2890	30.5	550	200	300
11	19.8	82.2	82.1	79.2	0.78	0.70	0.57	2880	36.5	550	190	300
13	23.8	82.4	82.0	78.8	0.77	0.68	0.54	2890	43.0	570	200	330
15	27.5	82.4	81.9	78.8	0.77	0.68	0.54	2890	50.0	570	190	320
18.5	33.5	82.7	82.4	79.2	0.77	0.68	0.55	2890	61.5	580	190	310
22	36.5	83.7	84.3	82.5	0.82	0.76	0.64	2880	73.5	560	170	280
26	43.5	84.0	84.3	82.4	0.82	0.76	0.63	2880	86.5	560	180	290
30	50.0	84.2	84.5	82.6	0.82	0.76	0.64	2880	100.0	560	180	300

Voltage code 09, 63

3 x 200 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	26.0	82.2	81.0	77.0	0.81	0.75	0.65	2910	18.0	650	190	320
7.5	34.5	82.5	82.1	79.0	0.83	0.78	0.68	2890	24.8	550	170	280
9.2	41.0	83.1	82.8	79.9	0.84	0.80	0.69	2890	30.5	560	180	270
11	47.5	83.5	83.6	81.2	0.85	0.81	0.72	2890	36.5	540	170	260
13	57.0	84.1	83.9	81.3	0.84	0.79	0.69	2900	43.0	570	180	300
15	66.0	84.2	84.1	81.4	0.84	0.79	0.68	2900	49.5	570	180	300
18.5	78.5	84.3	84.5	82.3	0.85	0.81	0.71	2890	61.0	560	180	280
22	94.5	84.3	84.6	82.4	0.85	0.81	0.70	2890	72.5	570	180	280

Voltage code 19, 69, 35

3 x 380 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	13.4	81.9	81.1	77.5	0.83	0.78	0.68	2900	18.0	610	170	300
7.5	17.8	82.3	82.2	79.6	0.84	0.80	0.70	2890	24.8	530	160	260
9.2	21.2	82.4	82.8	80.6	0.86	0.82	0.75	2880	30.5	500	150	240
11	25.0	82.3	83.2	81.6	0.86	0.84	0.77	2870	36.5	470	140	230
13	29.5	83.4	83.9	82.0	0.86	0.82	0.74	2880	43.0	520	160	260
15	34.0	83.6	84.0	82.0	0.86	0.82	0.73	2880	49.5	520	160	270
18.5	41.0	83.4	84.3	82.9	0.87	0.84	0.77	2870	61.5	500	150	250
22	49.5	83.5	84.4	83.0	0.87	0.84	0.76	2870	73.0	510	160	250

3 x 400 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	13.2	82.2	80.8	76.5	0.80	0.73	0.62	2910	18.0	660	200	330
7.5	17.2	82.8	82.2	78.9	0.82	0.76	0.65	2900	24.8	580	180	290
9.2	20.4	83.2	83.0	80.1	0.84	0.80	0.69	2890	30.5	560	180	270
11	23.8	83.3	83.5	81.2	0.85	0.81	0.72	2890	36.5	530	160	260
13	28.5	84.2	84.0	81.5	0.84	0.79	0.69	2900	43.0	570	180	300
15	33.0	84.2	84.0	81.3	0.84	0.79	0.68	2900	49.5	580	180	310
18.5	39.5	84.3	84.5	82.3	0.85	0.81	0.71	2890	61.5	560	180	280
22	47.5	84.3	84.6	82.4	0.85	0.81	0.70	2890	73.0	560	180	280

3 x 415 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	13.2	82.1	80.3	75.5	0.77	0.69	0.57	2920	18.0	690	220	360
7.5	17.2	83.0	81.9	78.2	0.80	0.72	0.60	2910	24.8	610	190	320
9.2	20.0	83.5	82.8	79.5	0.82	0.76	0.65	2900	30.5	590	190	290
11	23.4	83.7	83.5	80.7	0.83	0.79	0.68	2900	36.5	570	180	280
13	28.5	84.4	83.8	80.8	0.82	0.76	0.64	2910	43.0	610	200	330
15	33.0	84.4	83.7	80.5	0.81	0.75	0.63	2910	49.5	610	200	330
18.5	38.5	84.6	84.4	81.7	0.83	0.78	0.67	2900	61.5	590	190	310
22	46.5	84.7	84.4	81.7	0.83	0.77	0.66	2900	73.0	600	200	310

Voltage code 18

3 x 500 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	10.6	82.1	80.7	76.4	0.80	0.73	0.61	2920	18.0	660	200	330
7.5	13.8	82.7	82.1	78.9	0.82	0.77	0.66	2900	24.8	570	170	290
9.2	16.4	83.2	82.9	79.9	0.84	0.79	0.68	2900	30.5	570	180	270
11	19.0	83.2	83.5	81.4	0.86	0.82	0.73	2880	36.5	520	160	250
13	22.8	84.0	83.9	81.4	0.84	0.79	0.69	2900	43.0	570	180	300
15	26.0	84.2	84.1	81.4	0.84	0.80	0.69	2900	49.5	580	180	300
18.5	31.5	84.4	84.5	82.2	0.85	0.80	0.70	2890	61.0	570	180	290
22	38.0	84.3	84.5	82.4	0.85	0.81	0.70	2890	72.5	560	180	280

3 x 525 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %					
5.5	10.6	81.9	79.9	74.9	0.76	0.67	0.55	2920	18.0	700	230	380
7.5	13.6	82.9	81.8	77.9	0.79	0.71	0.59	2910	24.8	610	200	320
9.2	16.2	83.5	82.5	78.9	0.81	0.73	0.61	2910	30.5	610	200	310
11	18.4	83.8	83.6	80.8	0.83	0.78	0.68	2900	36.5	570	180	280
13	22.6	84.3	83.6	80.4	0.81	0.74	0.62	2910	43.0	610	200	330
15	26.0	84.5	83.7	80.5	0.81	0.74	0.62	2910	49.5	630	210	340
18.5	31.0	84.7	84.2	81.3	0.82	0.75	0.64	2900	61.0	610	210	330
22	37.5	84.6	84.2	81.4	0.82	0.76	0.64	2900	72.5	610	210	320

Voltage code 64

3 x 400 V, 50 Hz, T60

Power [kW]	Rated current $I_{1/1}$ [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRC [%]	LRT [%]	BT [%]
		100 %	75 %	50 %	100 %	75 %	50 %						
5.5	13.2	82.1	80.7	76.4	0.80	0.73	0.62	2910		18.0	660	200	330
7.5	17.4	82.7	82.1	78.7	0.82	0.76	0.65	2900		24.6	580	180	290
9.2	20.4	83.1	82.8	79.9	0.84	0.80	0.69	2890		30.5	560	180	270
11	23.8	83.3	83.4	81.1	0.85	0.81	0.72	2890		36.5	530	170	260
13	28.5	84.1	83.9	81.3	0.84	0.79	0.69	2900		43.0	570	180	300
15	33.0	84.2	84.1	81.4	0.84	0.79	0.68	2900		49.5	570	180	300
18.5	39.5	84.3	84.5	82.3	0.85	0.81	0.71	2890		61.0	560	180	280
22	47.5	84.3	84.6	82.4	0.85	0.81	0.70	2890		72.5	570	180	280

Voltage code 28, 30, 80

3 x 208 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [%of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	24.2	1.15	27.5	79.4	80.2	79.8	76.5	0.83	0.82	0.79	0.70	430
7.5	10	32.0	1.15	37.5	79.2	80.5	80.8	78.3	0.85	0.84	0.82	0.75	350
9.2	12	39.0	1.15	45.5	79.8	81.1	81.5	79.1	0.85	0.85	0.82	0.75	320
11	15	46.5	1.15	53.5	81.1	82.1	82.3	80.0	0.85	0.84	0.81	0.72	390
13	17	53.5	1.15	62.5	80.9	82.1	82.8	80.8	0.86	0.86	0.83	0.76	450
15	20	61.5	1.15	71.5	81.5	82.7	83.4	81.6	0.86	0.86	0.83	0.76	460
18.5	25	75.0	1.15	87.0	82.3	83.4	84.1	82.4	0.86	0.86	0.83	0.76	470
22	30	88.0	1.15	104	81.8	83.3	84.6	83.6	0.87	0.87	0.85	0.79	450
26	35	104	1.15	122	81.9	83.4	84.7	83.7	0.88	0.88	0.86	0.80	460
30	40	118	1.15	138	82.9	84.1	85.1	83.8	0.88	0.88	0.86	0.80	440

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3450	0.00372	17.6	120	220
7.5	10	3420	0.00441	24.0	120	210
9.2	12	3430	0.00507	29.5	120	220
11	15	3430	0.00567	35.0	130	230
13	17	3420	0.00639	41.5	130	230
15	20	3430	0.00716	48.0	120	220
18.5	25	3430	0.00836	59.0	120	230
22	30	3420	0.00968	70.5	110	210
26	35	3420	0.0110	83.5	100	210
30	40	3430	0.0125	96.0	130	230

3 x 220 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [%of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	23.4	1.15	26.5	80.5	80.6	79.5	75.4	0.82	0.81	0.75	0.64	490
7.5	10	30.5	1.15	35.0	80.8	81.4	81.0	77.6	0.84	0.83	0.79	0.69	400
9.2	12	37.0	1.15	42.5	81.3	82.0	81.6	78.4	0.84	0.83	0.79	0.69	370
11	15	44.5	1.15	50.5	82.4	82.8	82.3	79.2	0.83	0.82	0.77	0.66	440
13	17	51.0	1.15	58.5	82.4	83.1	83.0	80.2	0.85	0.84	0.80	0.70	510
15	20	58.5	1.15	67.0	82.9	83.7	83.5	80.9	0.85	0.84	0.80	0.70	520
18.5	25	71.5	1.15	82.0	83.6	84.3	84.2	81.6	0.85	0.84	0.80	0.69	540
22	30	83.0	1.15	96.5	83.5	84.5	85.0	83.1	0.87	0.86	0.83	0.74	520
26	35	97.5	1.15	112	83.6	84.5	85.1	83.2	0.88	0.86	0.83	0.76	530
30	40	112	1.15	130	84.4	85.2	85.3	83.2	0.88	0.86	0.83	0.74	510

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3470	0.00372	17.6	140	260
7.5	10	3450	0.00441	24.0	140	240
9.2	12	3450	0.00507	29.5	140	250
11	15	3460	0.00567	35.0	150	270
13	17	3450	0.00639	41.5	150	260
15	20	3450	0.00716	48.0	140	260
18.5	25	3460	0.00836	59.0	140	260
22	30	3450	0.00968	70.5	120	240
26	35	3450	0.0110	83.5	120	240
30	40	3460	0.0125	96.0	150	260

3 x 230 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [%of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	23.4	1.15	26.0	80.8	80.6	78.9	74.2	0.80	0.77	0.70	0.58	520
7.5	10	30.0	1.15	33.5	81.5	81.7	80.7	76.7	0.83	0.81	0.75	0.64	440
9.2	12	36.5	1.15	41.0	82.1	82.3	81.3	77.5	0.82	0.81	0.75	0.63	400
11	15	44.5	1.15	49.5	82.9	83.0	81.9	78.2	0.82	0.79	0.72	0.60	480
13	17	50.0	1.15	56.5	83.2	83.5	82.7	79.3	0.84	0.82	0.76	0.65	560
15	20	57.5	1.15	65.0	83.7	84.0	83.3	80.0	0.84	0.82	0.76	0.65	570
18.5	25	71.0	1.15	80.0	84.3	84.6	83.9	80.7	0.83	0.81	0.75	0.64	590
22	30	81.0	1.15	92.0	84.4	85.1	84.9	82.5	0.85	0.84	0.79	0.69	570
26	35	95.0	1.15	108	84.6	85.2	85.0	82.5	0.86	0.84	0.80	0.69	580
30	40	110	1.15	124	85.1	85.4	85.1	82.4	0.85	0.84	0.79	0.68	560

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3480	0.00372	17.6	160	280
7.5	10	3470	0.00441	24.0	150	260
9.2	12	3470	0.00507	29.5	150	280
11	15	3470	0.00567	35.0	170	300
13	17	3470	0.00639	41.5	160	290
15	20	3470	0.00716	48.0	160	290
18.5	25	3480	0.00836	59.0	160	290
22	30	3470	0.00968	70.5	140	270
26	35	3460	0.0110	83.5	140	270
30	40	3470	0.0125	96.0	170	290

Voltage code 33, 83

3 x 380 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	14.2	1.15	15.8	81.0	80.8	79.0	74.2	0.80	0.77	0.69	0.57	530
7.5	10	18.0	1.15	20.4	81.7	81.8	80.8	76.8	0.83	0.81	0.75	0.64	440
9.2	12	22.4	1.15	25.0	82.3	82.4	81.3	77.3	0.82	0.80	0.73	0.61	410
11	15	26.5	1.15	29.5	82.7	83.0	82.1	78.7	0.82	0.81	0.74	0.63	460
13	17	30.5	1.15	34.5	83.1	83.4	82.6	79.2	0.83	0.82	0.76	0.64	570
15	20	34.5	1.15	39.0	83.4	83.8	83.2	80.1	0.84	0.82	0.77	0.66	560
18.5	25	42.5	1.15	48.0	84.1	84.5	84.0	81.1	0.84	0.82	0.77	0.66	570
22	30	49.0	1.15	56.0	84.4	85.0	84.7	82.2	0.85	0.83	0.79	0.68	590
26	35	58.0	1.15	66.0	84.6	85.1	84.8	82.2	0.86	0.84	0.79	0.68	600
30	40	65.5	1.15	75.0	84.7	85.2	85.1	82.7	0.87	0.85	0.81	0.71	540

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3480	0.00372	17.4	160	290
7.5	10	3470	0.00441	23.8	150	260
9.2	12	3470	0.00507	29.0	160	280
11	15	3470	0.00567	35.0	160	280
13	17	3470	0.00639	41.0	170	290
15	20	3470	0.00716	47.5	150	280
18.5	25	3470	0.00836	58.5	150	280
22	30	3470	0.00968	69.5	140	270
26	35	3470	0.0110	82.5	140	280
30	40	3470	0.0125	95.0	160	280

3 x 400 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	14.6	1.15	15.8	80.8	80.2	77.8	72.2	0.75	0.71	0.63	0.50	560
7.5	10	18.2	1.15	20.2	81.9	81.7	80.0	75.3	0.80	0.77	0.69	0.57	480
9.2	12	22.8	1.15	25.0	82.3	82.1	80.4	75.7	0.78	0.75	0.66	0.54	430
11	15	26.5	1.15	29.5	83.0	82.8	81.4	77.2	0.79	0.76	0.68	0.55	500
13	17	31.0	1.15	34.0	83.3	83.3	81.9	77.7	0.80	0.77	0.69	0.56	610
15	20	35.0	1.15	38.5	83.7	83.7	82.5	78.7	0.81	0.78	0.70	0.57	600
18.5	25	42.5	1.15	47.0	84.4	84.3	83.3	79.7	0.81	0.78	0.70	0.58	620
22	30	49.5	1.15	55.0	84.9	84.9	84.2	80.9	0.82	0.80	0.72	0.59	630
26	35	58.0	1.15	64.5	84.9	85.0	84.2	80.8	0.82	0.80	0.72	0.59	650
30	40	65.5	1.15	73.0	85.2	85.3	84.7	81.6	0.84	0.82	0.75	0.63	590

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3500	0.00372	17.4	180	320
7.5	10	3480	0.00441	23.8	180	300
9.2	12	3490	0.00507	29.0	180	320
11	15	3480	0.00567	35.0	190	320
13	17	3480	0.00639	41.0	190	330
15	20	3480	0.00716	47.5	170	310
18.5	25	3490	0.00836	58.5	170	310
22	30	3480	0.00968	69.5	160	310
26	35	3480	0.0110	82.5	160	310
30	40	3480	0.0125	95.0	190	310

Voltage code 08

3 x 440 V, 60 Hz, T40, Undervoltage motors

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	13.4	1.15	14.4	81.0	80.3	77.9	72.3	0.75	0.70	0.62	0.50	560
7.5	10	16.2	1.15	18.0	81.8	81.7	80.2	75.8	0.81	0.78	0.71	0.59	470
9.2	12	19.6	1.15	21.8	82.2	82.2	80.9	76.8	0.81	0.79	0.71	0.59	420
11	15	23.4	1.15	26.0	83.0	83.0	81.8	77.9	0.81	0.78	0.71	0.58	480
13	17	28.0	1.15	31.0	83.5	83.4	82.1	78.0	0.81	0.77	0.69	0.57	610
15	20	31.0	1.15	34.5	83.9	84.0	83.0	79.4	0.82	0.80	0.72	0.60	590
18.5	25	39.0	1.15	43.0	84.3	84.2	83.2	79.5	0.81	0.78	0.70	0.57	620
22	30	44.0	1.15	49.5	85.3	85.4	84.6	81.5	0.83	0.80	0.73	0.60	640
26	35	50.0	1.15	56.5	84.7	85.3	84.9	82.4	0.86	0.84	0.79	0.68	600
30	40	58.5	1.15	66.0	85.2	85.4	84.9	81.9	0.84	0.82	0.76	0.65	580

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3500	0.00372	17.2	190	330
7.5	10	3480	0.00441	23.6	170	290
9.2	12	3480	0.00507	29.0	170	290
11	15	3480	0.00567	34.5	180	300
13	17	3480	0.00639	41.0	190	320
15	20	3480	0.00716	47.5	170	300
18.5	25	3490	0.00836	58.5	170	310
22	30	3480	0.00968	69.5	170	310
26	35	3470	0.0110	82.5	140	280
30	40	3480	0.0125	94.5	180	310

Voltage code 19, 35, 69

3 x 440 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	11.6	1.15	13.2	80.4	80.6	79.5	75.4	0.82	0.81	0.75	0.64	490
7.5	10	15.2	1.15	17.4	81.0	81.5	81.1	77.7	0.84	0.83	0.79	0.69	410
9.2	12	18.6	1.15	21.2	81.3	82.0	81.6	78.4	0.84	0.83	0.79	0.69	370
11	15	22.0	1.15	25.0	82.1	82.8	82.6	79.7	0.84	0.83	0.79	0.69	420
13	17	25.5	1.15	29.5	82.4	83.1	83.0	80.2	0.85	0.84	0.80	0.70	520
15	20	29.0	1.15	33.5	82.9	83.7	83.5	80.9	0.85	0.84	0.80	0.70	520
18.5	25	36.0	1.15	41.0	83.6	84.3	84.2	81.6	0.85	0.84	0.80	0.69	540
22	30	41.5	1.15	48.0	83.5	84.5	85.0	83.1	0.87	0.86	0.83	0.74	520
26	35	48.5	1.15	56.5	83.6	84.5	85.1	83.2	0.88	0.86	0.83	0.76	530
30	40	56.0	1.15	65.0	83.6	84.7	85.3	83.5	0.88	0.87	0.84	0.76	470

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3470	0.00372	17.4	140	260
7.5	10	3450	0.00441	23.8	140	240
9.2	12	3450	0.00507	29.5	140	250
11	15	3450	0.00567	35.0	140	250
13	17	3450	0.00639	41.5	150	260
15	20	3450	0.00716	47.5	140	260
18.5	25	3460	0.00836	58.5	140	260
22	30	3450	0.00968	70.0	130	240
26	35	3450	0.0110	83.0	120	240
30	40	3440	0.0125	95.5	140	240

3 x 460 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	11.6	1.15	13.0	80.8	80.6	78.9	74.1	0.80	0.77	0.70	0.58	520
7.5	10	15.0	1.15	16.8	81.7	81.8	80.8	76.8	0.83	0.81	0.75	0.64	440
9.2	12	18.2	1.15	20.6	82.1	82.3	81.3	77.5	0.82	0.81	0.75	0.63	400
11	15	21.6	1.15	24.4	82.8	83.1	82.4	78.9	0.83	0.81	0.75	0.64	460
13	17	25.0	1.15	28.5	83.2	83.5	82.7	79.3	0.84	0.82	0.76	0.65	560
15	20	29.0	1.15	32.5	83.7	84.0	83.3	80.0	0.84	0.82	0.76	0.65	570
18.5	25	35.5	1.15	40.0	84.3	84.6	83.9	80.7	0.83	0.81	0.75	0.64	590
22	30	40.5	1.15	46.0	84.4	85.1	84.9	82.5	0.85	0.84	0.79	0.69	570
26	35	47.5	1.15	54.0	84.6	85.2	85.0	82.5	0.86	0.84	0.80	0.69	580
30	40	54.5	1.15	62.0	84.7	85.2	85.2	82.8	0.86	0.85	0.80	0.70	520

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3480	0.00372	17.4	160	280
7.5	10	3470	0.00441	23.8	150	260
9.2	12	3470	0.00507	29.5	150	280
11	15	3470	0.00567	35.0	160	280
13	17	3470	0.00639	41.5	160	290
15	20	3470	0.00716	47.5	160	290
18.5	25	3480	0.00836	58.5	160	290
22	30	3470	0.00968	70.0	140	270
26	35	3460	0.0110	83.0	140	270
30	40	3460	0.0125	95.5	160	270

3 x 480 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	12.0	1.15	13.0	80.7	80.2	78.0	72.6	0.77	0.73	0.65	0.52	550
7.5	10	15.0	1.15	16.6	82.0	81.8	80.2	75.6	0.80	0.77	0.69	0.57	470
9.2	12	18.4	1.15	20.4	82.4	82.2	80.7	76.3	0.80	0.77	0.69	0.57	430
11	15	21.6	1.15	24.0	83.2	83.1	81.8	77.8	0.80	0.77	0.69	0.57	490
13	17	25.5	1.15	28.0	83.4	83.4	82.1	78.2	0.81	0.78	0.70	0.58	600
15	20	29.0	1.15	32.0	83.9	83.9	82.7	78.8	0.81	0.78	0.70	0.57	610
18.5	25	36.0	1.15	39.5	84.4	84.3	83.2	79.4	0.80	0.77	0.69	0.57	620
22	30	40.0	1.15	45.0	85.0	85.2	84.6	81.5	0.83	0.81	0.75	0.63	620
26	35	47.0	1.15	53.0	85.0	85.2	84.6	81.6	0.84	0.82	0.75	0.63	630
30	40	54.5	1.15	61.0	85.1	85.3	84.8	81.8	0.84	0.82	0.75	0.63	560

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3490	0.00372	17.4	180	310
7.5	10	3480	0.00441	23.8	170	290
9.2	12	3480	0.00507	29.5	170	310
11	15	3480	0.00567	35.0	180	310
13	17	3480	0.00639	41.5	180	320
15	20	3480	0.00716	47.5	180	320
18.5	25	3490	0.00836	58.5	170	320
22	30	3480	0.00968	70.0	160	300
26	35	3480	0.0110	83.0	150	300
30	40	3480	0.0125	95.5	180	300

Voltage code 18, 39

3 x 575 V, 60 Hz, T40

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	9.25	1.15	10.2	80.8	80.6	79.0	74.3	0.81	0.78	0.71	0.59	520
7.5	10	12.0	1.15	13.4	81.2	81.4	80.5	76.6	0.83	0.81	0.76	0.64	440
9.2	12	14.6	1.15	16.4	82.0	82.2	81.2	77.4	0.83	0.81	0.75	0.63	400
11	15	17.2	1.15	19.4	82.7	83.0	82.3	79.0	0.83	0.81	0.76	0.65	450
13	17	20.4	1.15	22.8	83.2	83.4	82.5	79.0	0.83	0.81	0.75	0.63	570
15	20	23.4	1.15	26.0	83.5	83.8	83.0	79.5	0.83	0.81	0.75	0.63	580
18.5	25	28.5	1.15	32.0	83.7	84.0	83.2	79.9	0.83	0.82	0.75	0.63	590
22	30	32.0	1.15	37.0	84.0	84.8	84.9	82.7	0.86	0.85	0.81	0.71	550
26	35	37.5	1.15	43.0	84.3	85.1	85.1	82.7	0.86	0.85	0.81	0.71	580
30	40	43.5	1.15	49.5	84.7	85.2	85.2	82.8	0.87	0.85	0.81	0.71	530

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3480	0.00372	17.4	160	280
7.5	10	3470	0.00441	23.8	150	260
9.2	12	3470	0.00507	29.0	150	270
11	15	3460	0.00567	35.0	160	280
13	17	3470	0.00639	41.0	170	300
15	20	3480	0.00716	47.5	160	290
18.5	25	3480	0.00842	58.5	160	290
22	30	3460	0.00968	70.0	130	260
26	35	3460	0.0110	82.5	140	260
30	40	3470	0.0125	95.0	160	270

Voltage code 09, 63

3 x 200 V, 60[rpm] Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	24.2	1.00	24.4	81.2	81.2	80.4	76.7	0.86	0.86	0.83	0.76	610
7.5	10	32.5	1.00	33.0	80.9	80.9	80.9	78.0	0.88	0.87	0.84	0.78	510
9.2	12	39.0	1.00	39.5	81.3	81.3	81.3	78.3	0.89	0.89	0.86	0.81	500
11	15	46.0	1.00	46.5	82.0	82.0	82.5	80.1	0.89	0.89	0.87	0.82	470
13	17	54.5	1.00	55.0	82.9	82.9	83.2	80.6	0.89	0.89	0.86	0.81	500
15	20	62.0	1.00	62.5	83.3	83.3	83.3	80.8	0.89	0.89	0.87	0.82	510
18.5	25	75.5	1.00	76.0	83.3	83.3	83.8	81.8	0.90	0.90	0.88	0.83	490
22	30	90.0	1.00	91.0	83.3	83.4	83.9	81.9	0.90	0.90	0.88	0.83	510

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3490	0.00507	15.0	150	270
7.5	10	3470	0.00567	20.6	130	220
9.2	12	3470	0.00639	25.5	130	210
11	15	3460	0.00716	30.5	130	210
13	17	3470	0.00836	35.5	160	260
15	20	3470	0.00961	41.5	130	260
18.5	25	3460	0.0110	51.0	130	240
22	30	3460	0.0125	60.5	120	240

3 x 220 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	22.6	1.00	22.6	82.1	82.1	80.4	75.8	0.83	0.83	0.79	0.69	740
7.5	10	30.0	1.00	30.0	82.4	82.4	81.4	77.6	0.85	0.85	0.81	0.72	620
9.2	12	36.0	1.00	36.0	82.8	82.8	81.8	78.0	0.87	0.87	0.83	0.76	620
11	15	42.0	1.00	42.0	83.7	83.7	83.0	79.8	0.88	0.88	0.84	0.77	590
13	17	50.0	1.00	50.0	84.3	84.3	83.4	80.1	0.87	0.87	0.83	0.75	620
15	20	57.0	1.00	57.0	84.5	84.5	83.6	80.2	0.87	0.87	0.83	0.76	630
18.5	25	68.5	1.00	68.5	84.8	84.8	84.3	81.4	0.88	0.88	0.85	0.78	620
22	30	82.0	1.00	82.0	84.8	84.8	84.3	81.4	0.89	0.89	0.85	0.78	630

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3510	0.00507	15.0	190	340
7.5	10	3500	0.00567	20.6	160	280
9.2	12	3500	0.00639	25.5	170	260
11	15	3490	0.00716	30.5	170	260
13	17	3500	0.00836	35.5	210	320
15	20	3500	0.00961	41.5	170	320
18.5	25	3490	0.0110	51.0	160	300
22	30	3490	0.0125	60.5	160	300

Voltage code 64

3 x 400 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	12.2	1.00	12.2	81.3	81.3	80.3	76.5	0.86	0.86	0.82	0.75	630
7.5	10	16.4	1.00	16.4	81.4	81.4	81.1	78.0	0.87	0.87	0.84	0.77	540
9.2	12	19.6	1.00	19.8	81.3	81.3	81.3	78.3	0.89	0.89	0.86	0.81	500
11	15	23.2	1.00	23.4	81.7	81.8	82.3	80.0	0.89	0.89	0.88	0.82	470
13	17	27.0	1.00	27.5	82.9	82.9	83.2	80.6	0.89	0.89	0.86	0.81	500
15	20	31.0	1.00	31.5	83.3	83.3	83.3	80.8	0.89	0.89	0.87	0.82	510
18.5	25	37.5	1.00	38.0	83.3	83.3	83.8	81.8	0.90	0.90	0.88	0.83	490
22	30	45.0	1.00	45.5	83.3	83.4	83.9	81.9	0.90	0.90	0.88	0.83	510

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3490	0.00507	15.0	160	290
7.5	10	3470	0.00567	20.6	130	240
9.2	12	3470	0.00639	25.5	130	210
11	15	3460	0.00716	30.5	130	210
13	17	3470	0.00836	35.5	160	260
15	20	3470	0.00961	41.5	130	260
18.5	25	3460	0.0110	51.0	130	240
22	30	3460	0.0125	60.5	120	240

3 x 440 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	11.4	1.00	11.4	82.1	82.1	80.3	75.5	0.83	0.83	0.78	0.67	760
7.5	10	15.2	1.00	15.2	82.7	82.7	81.4	77.4	0.84	0.84	0.80	0.70	650
9.2	12	18.0	1.00	18.0	82.8	82.8	81.8	78.0	0.87	0.87	0.83	0.76	620
11	15	21.0	1.00	21.0	83.5	83.5	82.9	79.7	0.88	0.88	0.84	0.77	590
13	17	25.0	1.00	25.0	84.3	84.3	83.4	80.1	0.87	0.87	0.83	0.75	620
15	20	28.5	1.00	28.5	84.5	84.5	83.6	80.2	0.87	0.87	0.83	0.76	630
18.5	25	34.5	1.00	34.5	84.8	84.8	84.3	81.4	0.88	0.88	0.85	0.78	620
22	30	41.0	1.00	41.0	84.8	84.8	84.3	81.4	0.89	0.89	0.85	0.78	630

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3520	0.00507	15.0	200	350
7.5	10	3500	0.00567	20.6	170	300
9.2	12	3500	0.00639	25.5	170	260
11	15	3490	0.00716	30.5	170	260
13	17	3500	0.00836	35.5	210	320
15	20	3500	0.00961	41.5	170	320
18.5	25	3490	0.0110	51.0	160	300
22	30	3490	0.0125	60.5	160	300

Voltage code 19, 69

3 x 440 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	11.8	1.15	13.2	81.6	81.1	79.0	73.8	0.83	0.82	0.77	0.67	610
7.5	10	15.6	1.15	17.4	82.2	82.0	80.5	76.1	0.84	0.83	0.79	0.69	520
9.2	12	18.2	1.15	20.8	82.2	82.2	80.9	76.9	0.87	0.86	0.82	0.74	500
11	15	21.4	1.15	24.6	82.4	82.7	81.9	78.4	0.88	0.86	0.83	0.76	470
13	17	25.5	1.15	29.0	83.5	83.6	82.5	79.0	0.87	0.86	0.82	0.73	510
15	20	29.5	1.15	33.5	83.6	83.6	82.5	78.8	0.87	0.85	0.82	0.73	530
18.5	25	35.0	1.15	40.0	83.9	84.2	83.5	80.5	0.88	0.86	0.83	0.76	510
22	30	42.0	1.15	48.0	84.0	84.2	83.6	80.6	0.88	0.86	0.83	0.76	520

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3500	0.00507	17.2	150	270
7.5	10	3480	0.00567	23.6	130	230
9.2	12	3480	0.00639	29.0	120	200
11	15	3470	0.00716	35.0	130	220
13	17	3480	0.00836	41.0	170	270
15	20	3480	0.00961	47.5	150	280
18.5	25	3470	0.0110	58.5	130	260
22	30	3470	0.0125	69.5	130	260

3 x 460 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	11.6	1.15	12.8	81.8	81.1	78.6	73.0	0.82	0.80	0.73	0.63	660
7.5	10	15.2	1.15	17.0	82.6	82.2	80.3	75.5	0.83	0.81	0.76	0.65	570
9.2	12	17.8	1.15	20.0	82.7	82.5	80.9	76.5	0.86	0.84	0.80	0.70	550
11	15	20.8	1.15	23.6	83.1	83.1	81.9	78.0	0.86	0.85	0.81	0.72	510
13	17	24.8	1.15	28.0	84.0	83.8	82.5	78.4	0.86	0.84	0.79	0.69	560
15	20	28.5	1.15	32.5	84.1	83.8	82.4	78.2	0.85	0.83	0.79	0.69	580
18.5	25	34.0	1.15	38.5	84.5	84.5	83.5	80.0	0.86	0.85	0.81	0.71	560
22	30	41.0	1.15	46.5	84.6	84.6	83.6	80.1	0.86	0.85	0.81	0.71	660

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3510	0.00507	17.2	160	290
7.5	10	3500	0.00567	23.6	140	250
9.2	12	3490	0.00639	29.0	140	220
11	15	3480	0.00716	35.0	150	240
13	17	3490	0.00836	41.0	190	300
15	20	3490	0.00961	47.5	170	310
18.5	25	3480	0.0110	58.5	150	280
22	30	3480	0.0125	69.5	160	290

3 x 480 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	11.6	1.15	12.6	81.8	80.9	78.0	72.1	0.79	0.76	0.69	0.57	700
7.5	10	15.0	1.15	16.6	82.8	82.2	79.9	74.8	0.81	0.79	0.71	0.60	610
9.2	12	17.6	1.15	19.6	83.1	82.7	80.7	75.8	0.84	0.82	0.76	0.65	590
11	15	20.4	1.15	22.8	83.6	83.3	81.8	77.5	0.85	0.83	0.78	0.68	560
13	17	24.6	1.15	27.5	84.3	83.9	82.1	77.7	0.83	0.82	0.75	0.64	610
15	20	28.5	1.15	31.5	84.3	83.9	82.0	77.5	0.83	0.81	0.75	0.63	620
18.5	25	33.5	1.15	37.5	84.9	84.7	83.3	79.4	0.85	0.83	0.78	0.67	610
22	30	40.5	1.15	45.0	84.9	84.7	83.4	79.4	0.84	0.82	0.77	0.66	630

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3520	0.00507	17.2	180	320
7.5	10	3510	0.00567	23.6	160	270
9.2	12	3500	0.00639	29.0	150	240
11	15	3490	0.00716	35.0	160	270
13	17	3510	0.00836	41.0	210	330
15	20	3500	0.00961	47.5	190	340
18.5	25	3500	0.0110	58.5	170	310
22	30	3500	0.0125	69.5	160	310

Voltage code 18

3 x 575 V, 60 Hz, T60

Power [kW]	Power [hp]	FL current $I_{1/1}$ [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ				LRC [% of I_{SF}]
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %	
5.5	7.5	9.30	1.15	10.2	81.7	81.0	78.5	72.9	0.82	0.79	0.72	0.62	670
7.5	10	12.0	1.15	13.6	82.4	82.1	80.3	75.5	0.83	0.82	0.76	0.66	560
9.2	12	14.2	1.15	16.0	82.7	82.5	80.8	76.3	0.85	0.83	0.79	0.69	560
11	15	16.6	1.15	18.8	83.0	83.1	81.9	78.2	0.87	0.85	0.82	0.73	500
13	17	19.8	1.15	22.4	83.9	83.7	82.4	78.3	0.86	0.84	0.79	0.69	560
15	20	22.8	1.15	25.5	84.0	83.8	82.4	78.3	0.86	0.84	0.80	0.69	580
18.5	25	27.5	1.15	31.0	84.6	84.6	83.5	79.9	0.86	0.84	0.80	0.70	570
22	30	33.0	1.15	37.0	84.5	84.5	83.6	80.1	0.86	0.85	0.81	0.71	580

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]	LRT [%]	BT [%]
5.5	7.5	3510	0.00507	17.2	170	300
7.5	10	3490	0.00567	23.6	140	250
9.2	12	3490	0.00639	29.0	140	220
11	15	3480	0.00716	34.5	140	230
13	17	3490	0.00836	41.0	190	300
15	20	3490	0.00968	47.0	170	300
18.5	25	3490	0.0110	58.5	150	290
22	30	3480	0.0125	69.5	140	280

Voltage code 20, 37

3 x 350 V, 100 Hz, T60

Power [kW]	Rated current [A]	Motor efficiency η [%]			Cos φ			n [rpm]	Rated torque [Nm]
		100 %	75 %	50 %	100 %	75 %	50 %		
4	9.6	89.2	87.4	83.6	0.92	0.96	0.98		12.7
5.5	12.6	90.3	89.3	86.8	0.92	0.94	0.97		17.5
7.5	16.6	90.5	90.3	88.9	0.88	0.92	0.95		23.9
9.2	21.4	91.8	90.8	88.2	0.94	0.96	0.98		29.3
11	25.0	92.2	91.6	89.6	0.93	0.95	0.97		35.0
13	29.2	92.4	92.0	90.6	0.92	0.94	0.96		41.4
15	33.4	92.4	92.2	91.2	0.88	0.91	0.94	3000	47.7
18.5	40.6	92.0	92.4	91.8	0.88	0.91	0.94		58.9
22	46.2	92.8	92.7	91.6	0.91	0.93	0.96		70.0
26	54.0	92.6	92.8	92.2	0.90	0.92	0.95		82.8
30	61.8	92.4	93.2	92.5	0.90	0.91	0.94		95,5
37	85.6	92.2	92.3	91.5	0.86	0.89	0.92		117.8
45	103.0	91.9	92.3	92.0	0.85	0.87	0.90		143.2

3 x 410 V, 120 Hz, T60

Power [kW]	Power [hp]	FL current [A]	Service factor	Rated current I_{SF} [A]	Motor efficiency η [%]				Cos φ			
					115 % (SF)	100 %	75 %	50 %	115 % (SF)	100 %	75 %	50 %
4	5.0	8.4	1.15	9.4	87.7	86.7	84.0	78.8	0.95	0.96	0.97	0.98
5.5	7.5	11.0	1.15	12.4	89.4	88.8	87.0	83.1	0.92	0.94	0.96	0.97
7.5	10	14.4	1.15	16.2	90.1	89.9	88.9	86.2	0.88	0.90	0.94	0.96
9.2	12	18.2	1.15	20.6	91.6	91.0	89.2	85.4	0.95	0.96	0.97	0.98
11	15	21.4	1.15	24.2	92.4	91.8	90.4	87.2	0.94	0.95	0.96	0.98
13	17	24.8	1.15	28.2	92.8	92.4	91.4	88.8	0.92	0.93	0.95	0.97
15	20	28.2	1.15	32.2	92.8	92.8	92.0	89.8	0.91	0.92	0.94	0.97
18.5	25	34.2	1.15	39.0	93.0	93.0	92.6	91.0	0.88	0.90	0.93	0.96
22	30	39.4	1.15	44.8	93.0	92.8	92.0	89.8	0.92	0.93	0.94	0.97
26	35	46.0	1.15	52.4	93.1	93.1	92.6	90.9	0.91	0.92	0.93	0.96
30	40	52.6	1.15	60.0	93.0	93.1	92.9	91.6	0.91	0.91	0.93	0.96
37	50	72.6	1.15	82.6	92.5	92.4	91.8	89.9	0.86	0.87	0.90	0.93
45	60	87.0	1.15	99.2	92.5	92.5	92.3	91.0	0.85	0.86	0.88	0.92

Power [kW]	Power [hp]	n [rpm]	Moment of inertia [kg•m^2]	Rated torque [Nm]
4	5.5	3600	0.00287	10.6
5.5	7.5			14.6
7.5	10			19.9
9.2	12		0.00496	24.4
11	15			29.2
13	17			34.5
15	20			39.8
18.5	25			49.1
22	30		0.00758	58.4
26	35			69.0
30	40			79.6
37	50		0.00984	98.1
45	60			119.4

9. Accessories

CSCR motor starters

The SA-SPM starter boxes are required to connect the MS6000 230V/60 Hz single-phase, 3-wire CSCR motors.

The motor starter boxes incorporate start/run capacitors for motor operation and start/run overload relays together with a surge arrestor for motor protection.

TM077903

SA-SPM

Product numbers

CSCR motor starters	CS [µF]	CR [µF]	Product number [18)]	Approval
5.0 hp/60 Hz	297	80	99053535	$_cUL_{us}$
7.5 hp/60 Hz	534	45	99053536	$_cUL_{us}$
10.0 hp/60 Hz	682	70	99053537	$_cUL_{us}$
15.0 hp/60 Hz	770	135	99053538	$_cUL_{us}$

18) Deluxe versions with on/off pressure switch relay for extra protection.

CUE frequency converter

GRA4404

CUE range

The Grundfos CUE is a series of external frequency converters designed for speed control of a wide range of Grundfos pumps.

The CUE offers quick and easy setup and commissioning compared to a standard frequency converter because of the startup guide. The startup guide takes the installer through all the necessary settings, requiring few inputs from which the CUE automatically sets all necessary parameters.

The CUE enables gentle pumping and thereby protects the water reservoir and the rest of the distribution system, as water hammer can be avoided by adjusting ramp times up and down.

When a CUE is installed, the motor requires no further overload protection. If needed, a Pt100 or Pt1000 together with the MCB 114 provides overheat protection of the motor windings.

If the motor has a built-in Tempcon sensor, this sensor is disconnected when it is exposed to the frequency converter drive. An internal fuse in the motor melts and it cannot be replaced. The motor works without the sensor, but it is not possible to restore the functionality of the Tempcon sensor.

Overview of the CUE range

Supply voltage [V]	Power range								
	[kW]	0.55	0.75	1.1	7.5	11	45	90	250
	[hp]	0.75	1.0	1.5	10	15	60	125	350
1 × 200-240				•	•				
3 × 200-240			•	•	•	•	•		
3 × 380-500		•	•	•	•	•	•	•	•
3 × 525-600			•	•	•	•	•	•	
3 × 525-690						•	•	•	•

The CUE is available in two enclosure classes:

- IP20/21
- IP54/55.

RFI filters

To meet the EMC requirements, The CUE includes the following types of built-in radio frequency interference filters (RFI).

Voltage [V]	Typical shaft power, P2 [kW (hp)]	RFI filter type	Application
1 × 200-240	1.1 - 7.5 (1.5 - 10)	C1	Domestic
3 × 200-240	0.75 - 45 (1.0 - 60)	C1	
3 × 380-500	0.55 - 90 (0.75 - 125)	C1	
	110 - 250 (150 - 350)	C3	Industry
3 × 525-600	0.75 - 90 (1.0 - 125)	C3	
3 × 525-690	11 - 250 (15 - 350)	C3	

Inputs and outputs

The CUE is equipped with a number of inputs and outputs:

- 1 RS-485 GENIbus connection
- 1 analog input, 0-10 V, 0/4-20 mA
  - external setpoint
- 1 analog input, 0-10 V, 0/4-20 mA
  - sensor input, feedback sensor
- 1 analog output, 0-20 mA
- 6 digital inputs
  - 2 inputs can be changed to digital outputs
  - all digital inputs and outputs are programmable
- 2 signal relays (C/NO/NC)
  - programmable.

Features

CUE has the following features:

- startup guide for easy setup of the CUE with Grundfos pumps (launched automatically the first time the CUE is connected to power supply, and relaunched upon request)
- checking of direction of rotation
- duty or standby operation
- dry-running protection
- low-flow stop function
- pump-specific functions.

Functions

The CUE has a wide range of pump-specific functions, such as the following:

- constant pressure
- constant level
- constant flow rate
- constant temperature
- constant curve.

Accessories

Grundfos offers various accessories for the CUE.

MCB 114 sensor input module

The MCB 114 is required to connect a Pt100/Pt1000 sensor, and offers additional analog inputs for the CUE:

- one analog input, 0/4-20 mA
- two inputs for the Pt100/Pt1000 temperature sensors.

Sensors

The following sensors can be used in connection with the CUE:

- pressure sensors, up to 25 bar
- temperature sensors
- differential-pressure sensors
- differential-temperature sensors
- flowmeters
- potentiometer box for external setpoint setting.

For further information, see the *CUE frequency converter data booklet* at the *Grundfos Product Center*.

Output filters

Output filters protect the motor from voltage peaks and increased operating temperature due to the frequency converter driving supply. The filters also decrease acoustic noise from the frequency converter-driven motor.

Always use sine-wave filters for a submersible motor installation.

See section *Frequency converter operation* for further information.

Related information

Frequency converter operation

Grundfos offering, CUE and Sine-wave easy selection for the MS6000P

400 V/50Hz grid supply, IP20

MS6000P motor 3×350 V, 100 Hz (3000 RPM)			CUE IP20 3×380-440 V			Sine-wave filter IP20/IP23 100 Hz			Motor cable (5 m)
Part number	Rated [kW]	Max. SF [A]	Part number	Rated [kW]	Max. output [A]	Part number	Current [A]	IP	Part number
76207712 [19]	4.0	9.6	99616713	4.0	10	96754976	13	IP20	96164209
	5.5	12.6	99616714	5.5	13				
			99616715	7.5	16				
	7.5	16.6	99616716	11	24	96754977	18	IP20	
76207717 [19]	9.2	21.4				96754978	26.5	IP20	
	11	25.0	99616717	15	32				
	13	29.2				96755019	36	IP20	
	15	33.4	99616718	18.5	37.5				
	18.5	40.6	99616719	22	44	96755021	46.5	IP20	
76207720 [19]	22	46.2	99616720	30	61	96755032	56	IP20	96164214
	26	54.0							
	30	61.8	99616721	37	73	97774436	86	IP23	
76207722 [19]	37	85.6	99616722	45	90	97775142	135	IP23	2 × 96164214 [20]
	45	103.0	99616723	55	106				

[19] Standard material version (EN 1.4301 - 304 ss), also available in R version (EN 1.4539 - 904L ss)

[20] Parallel motor cabling (DOL motor with two motor cables)

400 V/50Hz grid supply, IP54

MS6000P motor 3×350 V - 100 Hz (3000 RPM)			CUE IP55 3×380-440 V			Sine-wave filter IP54 100 Hz			Motor cable (5 m)
Part number	Rated [kW]	Max. SF [A]	Part number	Rated [kW]	Max. output [A]	Part number	Current [A]	IP	Part number
76207712 [19]	4.0	9.6	99616762	4.0	10	99995632	10	IP54	96164209
	5.5	12.6	99616763	5.5	13	99995643	17	IP54	
			99616764	7.5	16				
	7.5	16.6	99616765	11	24				
76207717 [19]	9.2	21.4				99995644	24	IP54	
	11	25.0	99616766	15	32	99995645	32	IP54	
	13	29.2							
	15	33.4	99616767	18.5	37.5	99995646	37.5	IP54	
	18.5	40.6	99616769	22	44	99995648	46	IP54	
76207720 [19]	22	46.2	99616770	30	61	99995649	61	IP54	96164214
	26	54.0							
	30	61.8	99616771	37	73	99995650	75	IP54	
76207722 [19]	37	85.6	99616772	45	90	99995651	90	IP54	2 × 96164214 [20]
	45	103.0	99616773	55	106	99995652	106	IP54	

[19] Standard material version (EN 1.4301 - 304 ss), also available in R version (EN 1.4539 - 904L ss)

[20] Parallel motor cabling (DOL motor with two motor cables)

If all the conditions in the table entitled *Requirements to operate the MS6000P without a sine-wave filter* in the section on Frequency converter operation are met, the sine-wave filter is not necessary.

Related information

Frequency converter operation

RSI frequency converter

The Grundfos Renewable Solar Inverter (RSI) is an off-grid solar inverter converting the DC power output from the solar panel to AC power supply for the pump operation.

The RSI can be used in both new and existing systems as long as the motor specifications are compatible and the motor is suitable for use with a variable frequency drive.

TM066678

Applications

The RSI is designed for continuous as well as intermittent operation, and it is suitable for various water supply systems, including irrigation.

The RSI can be used in existing systems with submersible pumps or dry-installed pumps, thus providing a very wide range of applications, allowing you to leverage renewable energy sources with the ability to back up the system with grid or generator power.

Features and benefits

Enclosure classes up to IP66

The RSI is available in three enclosure classes:

- IP21: The RSI must be installed in a cabinet with sufficient ingress protection.
- IP54: The RSI can be installed without a cabinet, but must not be installed outdoors without additional protection against water and sun.
- IP66: The RSI can be installed without a cabinet. It can be installed outdoors, but should be shaded from direct sunlight.

Setup wizard with Grundfos product library

The RSI has a built-in Grundfos product library that allows a plug-and-pump experience. The motor library contains all related parameters, which simplifies the setup process to just a few clicks and a setup time of a few minutes.

Detachable operating panel

The operating panel is mounted on the RSI via a magnet and a communication plug. The inverter can operate without the operating panel, and operates with the last saved setup data.

AC/DC compatibility

The RSI is AC and DC compatible. The RSI can be connected to the grid or a generator as back-up power during solar panel disruptions.

The AC compatibility also allows the end user to connect the inverter to three-phase power in their workshop for off-site setup, which enables a fast and simple on-site installation.

Maximum power point tracking (MPPT)

The inverter has built-in electronics with four MPPT algorithms. The inverter continuously optimises the power output according to available solar irradiation as well as various environmental conditions.

Overvoltage and undervoltage protection

Overvoltage and undervoltage may occur in case of faulty installation. The inverter disconnects the power connection to the motor if the voltage falls outside the allowed voltage limits. The inverter stays in fault mode with the error code displayed until reset.

Overload protection

Overload may occur if the maximum allowed frequency is set too high or a wrong pump is used. The inverter disconnects the power connection to the motor if overload occurs. The inverter stays in fault mode with the error code displayed until reset.

Overcurrent protection

Overcurrent may occur if, for example, a wrong cable size is used. The inverter disconnects the power connection to the motor if the current falls outside the allowed current limits. The inverter stays in fault mode with the error code displayed until reset.

Note that for the overcurrent protection to function properly, the actual current value must be adjusted according to the maximum current attained at the maximum frequency shortly after the system started operation.

Overtemperature protection

The inverter may be overheated if appropriate ventilation is not available or the ambient temperature is too high. The inverter disconnects the power connection to the motor if overtemperature occurs in the inverter. The inverter stays in fault mode with the error code displayed until reset.

By installing the Pt100/Pt1000 option board, the motor temperature can be monitored via the Pt100/Pt1000, and the motor can be protected against overtemperature.

No-load protection

No-load situation of the inverter may occur if, for example, the cable to the motor is broken. The inverter disconnects the power connection to the motor if no-load occurs. The inverter stays in fault mode with the error code displayed until reset.

For the no-load protection to function properly, check the RSI installation and operating instructions carefully and follow them during operation.

Operating history

The inverter stores historical operating data. The data can be retrieved through the menu on the inverter.

Communication

Built-in:

- Serial communication (RS485/Modbus)
- Ethernet IP
- Profinet IO
- Modbus TCP
- Bacnet IP.

Via optional boards:

- CanOpen
- Profibus DP
- DeviceNet
- Lonworks
- AS-interface.

Product numbers

Low voltage range (3 × 208-240 V)

Power [kW (hp)]	Product number	Electrical data		Frame size	IP class
		Max. P2 [kW (hp)]	Rated output current [A]		
1.5 (2)	99090622	1.5 (2)	8	A	IP66
2.2 (3)	99090633	2.2 (3)	11	A	
3.0 (4)	99090634	3.0 (4)	12.5	A	
4.0 (5)	99090635	4.0 (5)	18	B	
5.5 (7.5)	99090636	5.5 (7.5)	24.2	B	
7.5 (10)	99090637	7.5 (10)	31	B	
11 (15)	99090638	11 (15)	48	C	
15 (20)	99090639	15 (20)	62	C	

High voltage range (3 × 380-440 V)

Power [kW (hp)]	Product number	Electrical data		Frame size	IP class
		Max. P2 [kW (hp)]	Rated output current [A]		
2.2 (3)	99044348	2.2 (3)	5.6	A	IP66
3.0 (4)	99044349	3.0 (4)	8	A	
4.0 (5)	99044350	4.0 (5)	9.6	A	
5.5 (7.5)	99044351	5.5 (7.5)	12	A	
7.5 (10)	99044352	7.5 (10)	16	B	
11 (15)	99044363	11 (15)	23	B	
15 (20)	99044364	15 (20)	31	B	
18.5 (25)	99044365	18.5 (25)	38	C	
22 (30)	99044366	22 (30)	46	C	
30 (40)	99044367	30 (40)	61	C	
37 (50)	99044368	37 (50)	72	C	
45 (60)	99648886	45 (60)	87	MR7	IP54
55 (75)	99648887	55 (75)	105	MR7	
110 (150)	99648888	110 (150)	205	MR8	
132 (200)	99648889	132 (200)	261	MR9	
160 (250)	99648890	160 (250)	310	MR9	
200 (300)	99648891	200 (300)	385	ED	
250 (350)	99648892	250 (350)	460	ED	

Option boards

Description	Product number
Digital	99295565
Analog	99295551
Pt100/Pt1000	99295525

For further information, see the *RSI documentation* available at the *Grundfos Product Center*.

MP 204

MP 204 motor protector

The MP 204 is an electronic motor protector designed for the protection of an asynchronous motor.

The MP 204 cannot be used in installations where a frequency converter is installed.

The MP 204 operates with the following set of limits:

- warning limits
- trip limits.

If one or more of the warning limits are exceeded, the motor continues to run, but the warnings appear in the MP 204 display.

If one of the trip limits is exceeded, the trip relay stops the motor and an alarm appears on the MP 204 display. At the same time, the signal relay is operating to indicate that the limit is exceeded.

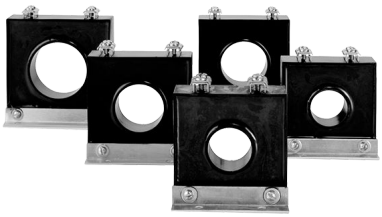
The details of warnings and alarms can be reviewed on the Grundfos GO remote app.

The MP 204 primarily protects the motor by measuring the motor current utilizing a true RMS measurement. The trip relay stops the motor if, for example, the current exceeds the preset value. Secondarily, the motor can be protected via temperature measuring by a Tempcon sensor, a Pt100/Pt1000 sensor, or a PTC sensor/thermal switch.

The MP 204 is designed for single- and three-phase motors. In single-phase motors, the starting and run capacitors are also measured. Cos ϕ is measured in both single- and three-phase systems.

The MP 204 directly measures motor currents up to 120A on the motor cables passing through the device. Five sizes of external single-turn transformers are available for motor currents higher than 120A and up to 999A.

The monitoring of the motor temperature via the Tempcon is not possible when single-turn transformers are used.



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Single-turn transformers

Applications

The applications of the MP 204 are the following:

- stand-alone motor protector
- remote monitoring via a Grundfos GENIbus.

Benefits

The MP 204 offers the following benefits:

- suitability for both single-phase and three-phase motors
- dry-running protection
- overload protection
- very high accuracy
- submersible pump-specific design
- insulation resistance measurement
- monitoring of the motor temperature throughout the motor cable in MS motors with a built-in Tempcon sensor (without the need for a control cable)
- direct measurement of motor currents up to 120A
- settings and status reading via the Grundfos GO remote app and GENIbus.

Monitoring options

The MP 204 monitors the following parameters:

- insulation resistance before start-up
- temperature (Tempcon, Pt100/Pt1000 sensor and PTC/thermal switch)
- overload or underload
- overvoltage or undervoltage
- current unbalance
- phase sequence
- phase failure
- power factor
- power consumption
- harmonic distortion
- operating hours and number of starts.

Grundfos GO remote app

The Grundfos GO Remote app offers easy access to setting options, status information, control and fault finding of the MP 204 on your Android or iOS-based device.

The Grundfos MI 301 mobile interface is required to connect the MP 204 with your device via Bluetooth. It has a rechargeable Li-ion battery that must be charged separately. Currently, Grundfos supports Android devices using Android 5.0 and later, and Apple devices using iOS 6.1.2 and later, but cannot guarantee operation on all devices in the market.

TM053890

MI 301

Communication

The MP 204 is prepared for the following communication modules:

- Grundfos Connect cellular (CIU 900 + CIM 280)
- Grundfos Connect IP (CIU 900 + CIM 550)
- PROFIBUS DP (CIU 900 + CIM 150)
- Modbus RTU (CUI 900 + CIM 200)
- Modbus Cellular/SMS (CUI 900 + CIM 260)
- Modbus TCP/PROFINET IO (CIU 900 + CIM 500).

Product numbers, MP 204

Product	Product number
MP 204	96079927
Grundfos Go Remote interface	
Grundfos MI 301 (with charger)	98046408
Grundfos MI 301 (without charger)	98761178
Single-turn transformers	
Current transformer ratio: 200:5, $I_{max.}$ = 200 A	96095274
Current transformer ratio: 300:5, $I_{max.}$ = 300 A	96095275
Current transformer ratio: 500:5, $I_{max.}$ = 500 A	96095276
Current transformer ratio: 750:5, $I_{max.}$ = 750 A	96095277
Current transformer ratio: 1000:5, $I_{max.}$ = 1000 A	96095278

For further information about motor protection via the MP 204, see the *MP 204 documentation* available at the *Grundfos Product Center*.

Technical data, MP 204

Enclosure class	IP20
Ambient temperature	-20 °C to +60 °C
Relative humidity	99 %
Voltage range	100-480 VAC
Current range	3-999 A
Frequency	50 to 60 Hz
IEC trip class	1-45
Special Grundfos trip class	0.1 to 30 s
Voltage variation	- 25 %/+ 15 % of rated voltage
Approvals	EN 60947, EN 60335, UL/CSA 508
Marking	CE, cUL, C-tick
Consumption	Max. 5 W
Plastic type	Black PC/ABS

Electrical data, MP 204

	Measuring range	Accuracy	Resolution
Current without external current transformers	3-120 A	± 1 %	0.1 A
Current with external current transformers	120-999 A	± 1 %	1 A
Phase-to-phase voltage	80-610 VAC	± 1 %	1 V
Frequency	47-63 Hz	± 1 %	0.5 Hz
Power	0-1 MW	± 2 %	1 W
Power factor	0 - 0.99	± 2 %	0.01
Energy consumption	0-4 x 10^9 kWh	± 5 %	1 kWh

Control MP 204

TM049512

The Control MP 204 cabinets are supplied with all necessary components to regulate the water supply by switching on and off a Grundfos SP pump when the installation reaches a certain water pressure or level. For this purpose, an external pressure switch or a flow switch must be connected to the control.

The integrated MP 204 device monitors and protects the motor of the pump. Additionally, the control cabinets have a built-in main switch and a thermal-magnetic circuit breaker. The MP 204 device is factory-set to an average current value, and must be adjusted during commissioning. Different models are available, depending on the motor size and the starting method.

Functions

- Demand-dependent on/off control
- protection against dry running
- fault indication
- motor monitoring and protection.

Communication

See the section on MP 204 communication options.

Technical data

Number of pumps	1
Enclosure class	IPS4
Ambient temperature	0° C to 40 °C
Relative humidity	95 %
Supply frequency	50 Hz
Supply voltage	3 × 400
Rated power	3.0 - 132 kW
Rated current	DOL 3 - 290 A
	SD 3 - 290 A
Motor connection	DOL or SD
Motor protection device	MP 204
Marking	CE, UKCA

Product numbers

Motor rated characteristics				
Voltage / Hz	Power	Current	Connection	
[V/Hz]	[kW]	[A]	Direct-On-Line (DOL)	Star-Delta (YD)
3 × 400 V / 50 Hz	3.0	3-8	99175449	99175463
	5.5	8-14.5	99175450	99175464
	9.2	14.5-23.5	99175451	99175465
	13.0	23.5-30.0	99175452	99175466
	15.0	30.0-36.5	99175453	99175467
	18.5	36.5-45	99175454	99175468
	26.0	45-61	99175455	99175469
	30.0	61-75	99175456	99175470
	37.0	75-85	99175457	99175471
	55.0	85-120	99175458	99175472
	75.0	120-156	99175459	99175473
	90.0	156-180	99175460	99175474
	110.0	180-235	99175461	99175475
	132.0	235-290	99175462	99175476

For further information, see the *Control MP 204 documentation* available at the *Grundfos Product Center*.

CIU communication interface units

TM078946

Grundfos Communication Interface Unit (CIU)

A CIU is required for complete control of the pump system and the data communication between the main network and an SP pump with a CUE, RSI or MP 204. The CIU enables data communication via open and interoperable networks, such as the following:

- LON
- PROFIBUS DP
- PROFINET IO
- Modbus RTU
- Modbus TCP
- Ethernet/IP
- BACnet MS/TP
- BACnet IP
- Grundfos Connect.

Applications

The range of Grundfos CIU offers ease of installation and commissioning as well as user-friendliness. All units are based on standard functional profiles for an easy integration into the network.

The CIU devices enable communication of operating data, such as measured values and setpoints, between the pump and the following:

- PLC
- SCADA system
- building management system
- Grundfos Connect.

Benefits

- Open communication standards
- complete process control
- one concept for the Grundfos products
- 24-240 VAC/DC power supply in CIU devices
- simple configuration and easy installation
- readiness for DIN rail or wall mounting.

Product numbers

To create the necessary control unit, a CIU must be ordered with the Communication Interface Module (CIM) required for the Fieldbus protocol. Use the table below for the selection:

Product	Product number
CIU 900	99448387
CIM 100	96824797
CIM 150	96824793
CIM 200	96824796
CIM 300	96893770
CIM 500	98301408
CIM 260-EU [21]	99439302
CIM 260-US [21]	99439306
CIM 280-EU [22]	99895383
CIM 280-US [22]	99895386
Antenna EU	99518079
Antenna US	98851149
Mounting bracket for Antenna-US	99606614
Grundfos Connect subscription - one year	92711156

[21] 3G/4G SIM card required

[22] eUICC SIM card included

Fieldbus support protocols

Protocols		MP 204	CUE	RSI
GENIbus		built-in	built-in	N/A
LON		N/A	CIU 900 + CIM 100	optional
PROFIBUS DP		CIU 900 + CIM 150		optional
PROFINET IO		CIU 900 + CIM 500		built-in
Modbus RTU		CIU 900 + CIM 200		built-in
Modbus TCP		CIU 900 + CIM 500		built-in
Modbus cellular [23] [24]	EU	CIU 900 +CIM 260-EU + Antenna-EU + SIM card [25]		N/A
	US	CIU 900 +CIM 260-US + Antenna-US + SIM card [25] + Mounting bracket for Antenna-US		N/A
EtherNet/IP		N/A	CIU 900 + CIM 500	built-in
BACnet MS/TP		N/A	CIU 900 + CIM 300	N/A
BACnet IP		N/A	CIU 900 + CIM 500	built-in
Grundfos Connect IP [26] [27]		CIU 900 + CIM 500		
Grundfos Connect cellular [23] [27]	EU	CIU 900 + CIM 280-EU [28] + Antenna-EU		
	US	CIU 900 + CIM 280-US [28] + Antenna-US + Mounting bracket for Antenna-US		

[23] Available in regional versions for EU and USA (consider needed 3G/4G frequency bands)

[24] Cellular data connection for SCADA and SMS

[25] 3G/4G SIM card required for the CIM 260

[26] Wired internet connection required

[27] One-year subscription required for the Grundfos Utility Connect service

[28] eUICC SIM card included in the CIM 280

For further information about data communication via the CIU and fieldbus protocols, see the *CIM/CIU documentation* available at the *Grundfos Product Center*.

PR 5714

The PR 5714 is a programmable LED indicator with relay output. In combination with a Pt100/Pt1000 sensor, it offers the following features:

- continuous monitoring of the motor temperature
- protection against too high temperature.

The Pt100/Pt1000 sensor measures the temperature, and the PR 5714 monitors it, ensuring that the preset values are not exceeded. If the preset values are exceeded, the PR 5714 relay disconnects the contactor.

Monitoring and protection employing a Pt100/ Pt1000 require the following parts:

- Pt100 or Pt1000 sensor
- PR 5714 relay
- sensor cable.

The following temperature limits are preset on delivery:

- 60 °C warning limit
- 75 °C stop limit.

The temperature limits must be adjusted during the start-up based on the temperature at maximum load in normal operation. The following temperature limits are preset in the PR 5714 on delivery:

- 60 °C warning limit
- 75 °C stop limit.

Technical data

Enclosure class	IP65 (fitted in a control panel)
Ambient temperature	-20 °C to +60 °C
Relative air humidity	95 % (condensating)
Voltage variation	1 x 24-230 VAC ± 10 %, 50-60 Hz 24-250 VDC ± 20 %
Approvals	UL, DNV
Marking	CE

Product number

PR 5714 relay	Voltage	Product number
	24-230 VAC, 50/60 Hz / 24-250 VDC	96913234

Pt100

A Pt100 temperature sensor can be installed to monitor the temperature of MS6000(P) motors. In applications with frequency converter, a Pt100 must be used instead of the built-in Tempcon.

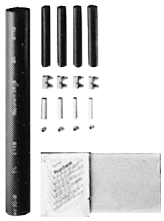
To mount the Pt100, one of the motor studs must be replaced by a staybolt for the Pt100. To mount the Pt100 in MS6000(P) motors with flange extension, contact Grundfos.

Temperature monitoring is done via the PR 5714, MP 204, CUE, RSI or another monitoring device prepared for reading the Pt100 signal. The temperature limits for motor protection must be set on the monitoring device during start-up, according to the normal operating conditions. To set the warning and alarm (trip) limits, add 5 °C and 10 °C to the stable temperature of the motor during normal operation at maximum load, reflecting the highest current demand. If a sensor cable longer than 100 m is required, a 20 m sensor with cable can be spliced to the required drop sensor cable length. The recommended maximum total length is 350 m.

Pt100 sensor, including cable	Cable length [m]	Product number
	20	96913237
	40	96913253
	60	96913256
	80	96913260
	100	96913263

Staybolt kits for Pt100 - MS6000(P) without flange extension	Description	Product number
	Staybolt kit for Pt100 Material: EN 1.4401/AISI 316	97550639
	Staybolt kit for Pt100 [29] Material: EN 1.4539/AISI 904L	96803373

[29] To mount a Pt100 on MS6000(P) motors with flange extension, contact Grundfos.

Extension kit for sensor cable for Pt100 and Pt1000	Description	Product number
	Extension kit for Pt100 and Pt1000 sensor cable [30] For watertight shrink-joining of the sensor cable	99039717

[30] Extra sensor cable must be ordered separately.

Drop sensor cable	Description	Product number
	Drop cable for extension: 4 × 1 mm^2 Maximum recommended length: 350 m [31]	00RM5271

[31] Mention length when ordering.

Model C motor cables

Motor type	Length [m]	Jacketed flat cable (for CE-approved motors)		Single leads (for cCSAus-approved motors)	Single leads (for BM booster applications)
		EPDR rubber		XLPE rubber	
		4 G 6 mm^2	4 G 10 mm^2	4 x 1 G 8AWG	3 x 1 x 8AWG
MS6000 and MS6000P	3	-	-	96164227	-
	5	96164209	96164214	96164228	-
	8	96164210	-	-	-
	10	96164211	96164215	-	-
	20	96164212	96164216	-	-
	30	96164213	96164217	-	-
	31	-	-	96164229	-
	50	-	96164218	-	-
	65	-	96164219	-	-
	67	-	-	96164230	-
	100	-	96164220	-	-
MS6000 and MS6000P with flange extension	3	-	-	96164221	-
	5	-	-	96164222	-
	31	-	-	96164223	-
	67	-	-	96164224	-
MS6000 and MS6000P for booster applications	5	-	-	-	96164225
	8	-	-	-	96164226
MS6000R and MS6000PR	3	-	-	96300135	-
	5	96300112	96300123	96300136	-
	10	96300113	96300124	-	-
	15	96300114	96300125	-	-
	20	96300115	96300126	-	-
	25	96300116	96300127	-	-
	30	96300117	96300128	96300137	-
	40	96300118	96300129	-	-
	50	-	96300130	-	-
	60	96300119	-	96300138	-
	70	-	96300131	-	-
	90	96300120	-	-	-
	100	96300121	96300132	-	-
MS6000R and MS6000PR for booster applications	5	-	-	-	96300133
	8	-	-	-	96300134

Long motor cables that do not work completely submerged in water must be sized to work in the air. Otherwise, the motor cables must work submerged in water.

Submersible drop cable

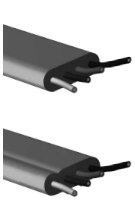
Product	Description	Number of leads and nominal cross-section [mm²]	Min./max. outer cable diameter [mm]	Weight [kg/m]	Product number
	Suitable for the following applications: • continuous application in groundwater and potable water (approved for potable-water applications) • connection of electrical equipment (e.g., submersible motors) • installation depths up to 2000 m and average loads. It has an ozone-, water- and weather-resistant insulation and a sheath made of special EPR-based elastomer materials. Maximum permissible water temperature: 60 °C. Maximum permissible lead service temperature: 90 °C. Further cable sizes are available. For more information, see the *Grundfos Product Center*.	1 × 16	11.0 / 14.5	0.280	00ID4071
		1 × 25	12.5 / 16.5	0.365	00ID4072
		1 × 35	14.0 / 18.5	0.490	00ID4073
		1 × 50	16.5 / 21.0	0.690	00ID4074
		1 × 70	18.5 / 23.5	0.920	00ID4075
		1 × 95	21.0 / 26.5	1.210	00ID4076
		1 × 120	23.5 / 28.5	1.455	00ID4077
		1 × 150	26.0 / 31.5	1.825	00ID4078
		1 × 185	27.5 / 34.5	2.160	00ID4079
		4G1.5	10.5 / 13.5	0.165	00ID4063
		4G2.5	12.5 / 15.5	0.235	00ID4064
		4G4.0	14.5 / 18.0	0.335	00ID4065
		4G6.0	16.5 / 22.0	0.460	00ID4066
		4G10	22.5 / 24.5	0.800	00ID4067
		4G16	26.5 / 28.5	1.165	00ID4068
		4G25	32.0 / 34.0	1.650	00ID4069
		4G35	33.0 / 42.5	2.200	96432949
		4G50	38.0 / 48.5	3.260	96432950
		4G70	43.0 / 54.5	4.149	96432951

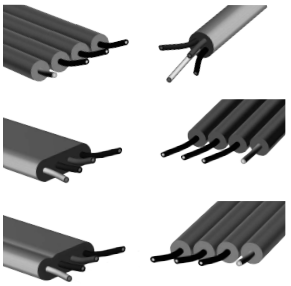
Related information

10. Cable sizing

Cable termination kit, type KM

For instruction on how to make the cable termination between motor cable and drop cable, see the *KM quick guide* available at the *Grundfos Product Center*.

Possible cable termination		Content of kit	Motor cable [mm²]	Drop cable [mm²]	Number of leads	Product number
Motor cable	Drop cable					
			KM kits with pressed connections:			
			1.5 - 6	1.5 - 6	4	00116251
			6 - 16	6 - 16	4	00116252
			10 - 25	10 - 25	4	00116255
			KM kits with screw connectors:			
			6 - 35	6 - 35	4	96636867
			25 - 70	25 - 70	4	96636868

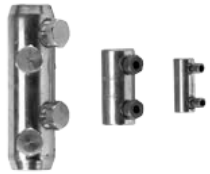
Possible cable termination		Content of kit	Motor cable [mm²]	Drop cable [mm²]	Number of leads	Product number
Motor cable	Drop cable					
			KM kits with pressed connections:			
			1.5 - 6	1.5 - 6	4	00116257
			6 - 16	6 - 16	4	00116258
			10 - 50	10 - 50	4	96637330
			16 - 70	16 - 70	4	96637332
			1.5 - 6	1.5 - 6	3	00116253
			10 - 25	10 - 25	3	00116254
			10 - 50	10 - 50	3	96637318
			16 - 70	16 - 70	3	96637331

Possible cable termination		Content of kit	Motor cable [mm²]	Drop cable [mm²]	Number of leads	Product number
Motor cable	Drop cable					
			KM kits with pressed connections:			
			10-70	10-70	1	96828296
			32-120	32-120	1	00116256
			KM kits with screw connectors:			
			70-240	70-240	1	96637279

A KM termination kit for single leads only consists of material for one connection. When ordering, keep in mind how many kits are needed for a complete cable termination.

Cable termination kit, types M0 to M4

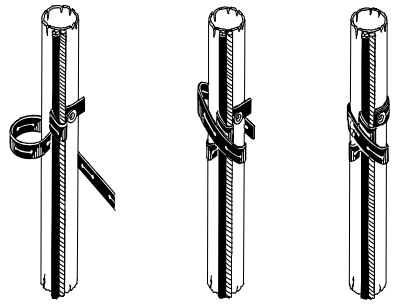
Product	Description	Version			Product number
		Type	Diameter of cable joint [mm]	Outer cable diameter [mm]	
	This kit is for watertight joining of motor cables and submersible drop cables. The joint is encapsulated by the glue which is part of the kit.	M0	Ø40	Ø6 - Ø15	00ID8903
		M1	Ø46	Ø9 - Ø23	00ID8904
		M2	Ø52	Ø17 - Ø31	00ID8905
		M3	Ø77	Ø26 - Ø44	00ID8906
		M4	Ø97	Ø29 - Ø55	91070700

		Cross-section of leads [mm²]	Number of connectors	Product number
	These are accessories for cable kits M0 to M4. These are the screw connectors only.	6-25	4	96626021
		16-95		96626022
		35-185		96626023
		70-240		96626028

When ordering this cable termination kit, the screw connectors are not included. For ordering suitable screw connectors, see the table below.

In high pressure, high temperature or sea water applications, use the type KM cable termination kits.

Cable clips

Product	Description	Product number
	The clips are for fastening cable and straining wire to the riser pipe: • fitted every 3 metres • one set for approx. 45 m of riser pipe • 16 cable buttons • 7.5 m rubber band.	115016

Zinc anodes

Cathodic protection by zinc anodes protects submersible motors against corrosion in chloride-containing liquids, such as brackish water and seawater.

The sacrificial anodes are placed on the outside of the motor, increasing the motor diameter by a minimum of 40 mm. To ensure proper electric and metallic contact between the clamp and the motor surface, the motor surface must be cleaned thoroughly before a new anode string is fitted, and the anode strings must be fastened tightly. The distance between the anode strings must be identical.

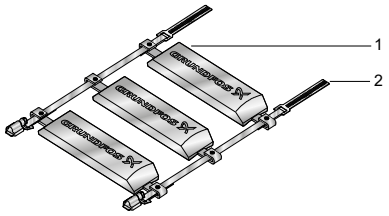
During operation, the material of the zinc anodes is reduced, and the anodes become gradually covered by corrosion products, which obstructs the direct metallic contact between the anode and the motor surface. To counteract this, the metallic contact must be ensured through the clamp, keeping tight contact with the motor by adjusting the clamp.

Inspection must be made at regular intervals to ensure the functioning of the galvanic cathodic protection system. The first inspection is recommended after six months, while the following subsequently approximately once a year.

The life of a zinc anode is 1 to 4 years, depending on the operation conditions.

The number of anodes required depends on the operation conditions, the pump, and the motor in question.

The following tables show the available kits and the number of anode strings recommended for each motor model. Contact Grundfos for further details.



TM078809

Anode string components

Pos.	Description	Part
1	1 pc. zinc anode cast around the clamp	PN 99722879
2	2 pcs. stainless steel clamps	PN 99812400

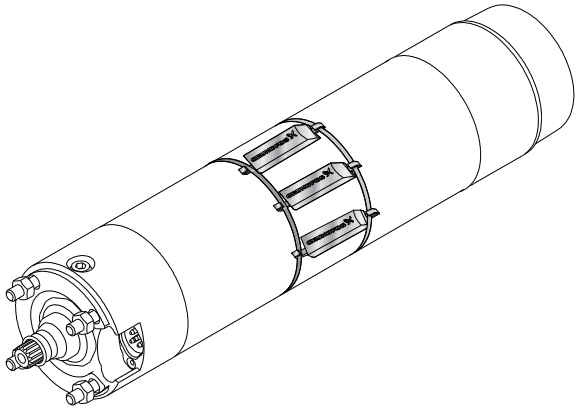
Anode string kits

Kit no.	Kit contents
92836041	1 × 99812400, 2 × 99722879
92836043	1 × 99812400, 4 × 99722879
92621545	1 × 99812400, 6 × 99722879

TM083095

Anode string kit with 2 anodes

Zinc anodes for MS - MMS motors			
Motor	Length	Recommended number of anode strings	Ordering
			Product number
MS402	Up to 350 mm	1	92836041
MS4000	Up to 1000 mm	1	92836041
MS6000	Up to 1000 mm	1	92836043
MMS6	Up to 1000 mm	1	92836043
MMS6	1000 to 1400 mm	2	92836043
MMS8000	Up to 1000 mm	1	92836043
MMS8000	1000 to 2060 mm	2	92836043
MMS10000	Up to 2000 mm	2	92621545
MMS10000	2000 to 2500 mm	3	92621545
MMS12000	Up to 2000 mm	2	92621545
MMS12000	2000 to 2300 mm	3	92621545



TM086185

One anode string on the MS submersible motor

Flow sleeves

Grundfos offers a complete range of stainless steel flow sleeves for vertical and horizontal operation. The selection depends on the combined SP pump and the motor assembly. For more information, review the *SP Accessories Data Booklet* available at the *Grundfos Product Center*.

TM078415

Flow sleeves

10. Cable sizing

Grundfos offers round single-core and multicore submersible drop cables. Drop cables for Grundfos 6" submersible motors are available with a plug for easy connection to the motor cable.

The submersible drop cable must be sized to work in air based on:

- the allowed voltage drop in its entire length (from the motor starter to the motor terminals)
- the current capacity of its cross-section at the maximum air temperature at which the cable works.

The voltage supplied at the motor terminals must always be within the motor voltage tolerances. For this reason, the voltage drop in the cable and other systems between the voltage source and the motor terminals must be considered or limited.

Grundfos recommends allowing a maximum voltage drop of 1 % to 3 % in the drop cable.

Additionally, the energy losses in the cable are proportional to the voltage drop, thus limiting the voltage drop may save energy.

Local and national requirements regarding cable sizing and selection must always be followed and they may demand the use of a bigger cross-section than the one computed by the following formulas and tables.

The cable properties used in the following formulas and tables correspond to Grundfos submersible drop cables. If other brands are used, contact your cable supplier for guidance.

Related information

Submersible drop cable

Calculation of the cross section

Use the following formula to calculate the minimum required cross-section of a cable as a function of the installation length for a three-phase submersible pump.

Single-phase motor

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

Three-phase motor (DOL)

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

Three-phase motor (Star-delta)

$$q = \frac{I \times 100 \times L \times \rho \times \cos\varphi}{U \times \Delta U - (I \times 100 \times L \times X_L \times \sin\varphi)}$$

Calculation of the maximum cable length

The maximum cable length for a given cable cross-section can be calculated by the following formulas.

Single-phase motor

$$L = \frac{U \times \Delta U}{I \times 2 \times 100 \times \left(\cos\varphi \times \frac{\rho}{q} + \sin\varphi \times X_L\right)} \quad [m]$$

Three-phase motor (DOL)

$$L = \frac{U \times \Delta U}{I \times 1.73 \times 100 \times \left(\cos\varphi \times \frac{\rho}{q} + \sin\varphi \times X_L\right)} \quad [m]$$

Three-phase motor (Star-delta)

$$L = \frac{U \times \Delta U}{I \times 100 \times \left(\cos\varphi \times \frac{\rho}{q} + \sin\varphi \times X_L\right)} \quad [m]$$

The maximum cable length may be based on the maximum operating current when it is lower than the rated current of the motor. For example, if the maximum operating current is 10 % lower than the rated current of the motor, the cable may be 10 % longer than the value computed with the formula or indicated in the tables.

Calculation of the energy loss

The cross-section of the cable determines the energy losses throughout its length. To minimize operating losses, the cable cross-section may be increased compared to what is calculated based on the maximum allowed voltage drop. This is only economical if the borehole provides the necessary space and if the operational time of the pump is long. The energy loss is computed by multiplying the power loss with the operating hours.

The following formula can be used to calculate the power loss in the cable of a three-phase system.

$$\Delta p = \frac{3 \times L \times \rho \times I^2}{q} \quad [W]$$

Formula designations	
ΔU	Allowed voltage drop in the cable: 1 to 3 [%]
U	Rated voltage [V]
I	Rated current [A]
cos φ	Rated power factor
q	Cable cross-section [mm^2]
ρ	Cable specific resistance: 0.025 [$\Omega.mm^2/m$]
X_L	Cable inductive resistance: 0.078 × 10^{-3}[Ω/m]
L	Cable length [m]
Δp	Power loss [W]
sin φ	$\sqrt{1 - \cos^2\varphi}$

Selection tables

For an easy selection, the tables below indicate the maximum length of Grundfos submersible drop cables for different cross-sections. The cable length is calculated based on a maximum voltage drop of 3 % and air temperature of 30 °C.

MS6000 T40 motors at 3 × 400V, 50 Hz, DOL
Voltage drop 3 %
Maximum cable lengths [m]

P2	P2	Imax	Cos φ	Cable cross-section [mm²]												
kW	hp	[A]	-	6.0	10	16	25	35	50	70	95	120	150	185	240	300
3.7	5	8.9	0.78	236	390	615	940									
5.5	7.5	13.4	0.78	157	259	408	625	854								
7.5	10	17.2	0.82	117	193	304	466	640	887							
9.5	12	21.2	0.82	95	156	247	378	519	720	969						
11	15	25.0	0.82	80	132	209	321	440	610	822						
13	17	29.0	0.82	69	114	180	277	379	526	709	918					
15	20	33.5	0.82	60	99	156	239	328	455	614	795	961				
18.5	25	41.0	0.82	49	81	128	196	268	372	501	650	785	933			
22	30	47.5	0.84	41	68	108	166	227	316	427	554	672	801	937		
26	35	55.5	0.85		58	91	140	193	268	363	472	573	684	801	964	
30	40	64.0	0.85		50	79	122	167	233	314	409	497	593	695	836	968
Cable current capacity in air at 30 °C [A]				53	74	99	131	162	202	250	301	352	404	461	547	633

For motors with star-delta starting, the cable length can be calculated by multiplying the relevant cable length from the above tables by $\sqrt{3}$.

MS6000 T60 motors at 3 × 400V, 50 Hz, DOL
Voltage drop 3 %
Maximum cable lengths [m]

P2	P2	Imax	Cos φ	Cable cross-section [mm²]										
kW	hp	[A]	-	6.0	10	16	25	35	50	70	95	120	150	185
3.7	5	8.7	0.82	230	381	601	922							
5.5	7.5	13.2	0.80	155	257	405	621	850						
7.5	10	17.2	0.82	117	193	304	466	640	887					
9.5	12	20.4	0.84	96	159	251	385	529	735	993				
11	15	23.8	0.85	81	135	213	327	450	625	846				
13	17	28.5	0.84	69	114	180	276	379	526	711	924			
15	20	33.0	0.84	59	98	155	238	327	455	614	798	967		
18.5	25	39.5	0.85	49	81	128	197	271	377	510	663	805	961	
22	30	47.5	0.85	41	67	107	164	225	313	424	552	669	799	936
Cable current capacity in air at 30 °C [A]				53	74	99	131	162	202	250	301	352	404	461

For motors with star-delta starting, the cable length can be calculated by multiplying the relevant cable length from the above tables by $\sqrt{3}$.

MS6000P T60 motors at 3 × 350V, 100 Hz, DOL
Voltage drop 3 %
Maximum cable lengths [m]

P2 kW	P2 hp	Imax [A]	Cos φ -	Cable cross-section [mm²]												
				6.0	**10**	**16**	**25**	**35**	**50**	**70**	**95**	**120**	**150**	**185**	**240**	300
4.0	5.0	9.6	0.95	159	263	419	649	899								
5.5	7.5	12.6	0.92	125	207	328	507	700	982							
7.5	10	16.6	0.88	99	163	259	399	549	766							
9.2	12	21.4	0.94	72	119	190	293	406	571	783						
11	15	25.0	0.93	62	103	164	253	350	492	673	888					
13	17	29.2	0.92	54	89	142	219	302	424	579	762	935				
15	20	33.4	0.88	49	81	129	198	273	381	517	676	825	989			
18.5	25	40.6	0.88	40	67	106	163	225	313	425	557	678	814	958		
22	30	46.2	0.91		57	90	139	193	270	368	483	592	714	846		
26	35	54.0	0.90		49	78	120	166	232	316	415	507	611	722	880	
30	40	61.8	0.90		43	68	105	145	203	276	363	443	534	631	769	901
37	50	85.6	0.86			51	79	108	151	204	266	324	387	454	548	636
45	60	103	0.85				66	91	126	171	223	270	322	378	455	526
With parallel drop cabling [32]																
37	50	85.6	0.86		65	102	158	217	302	409	533	648	774	909		
45	60	103	0.85		54	86	132	182	253	342	445	540	645	756	909	
Cable current capacity in air at 30 °C [A]				53	74	99	131	162	202	250	301	352	404	461	547	633

[32] For 37 and 45 kW MS6000P with parallel motor cabling (DOL motor with two motor cables), it is recommended to join the motor cables to individual drop cables, that is, use parallel drop cabling, up to the borehole head.

For other voltages, see the cable sizing tool at the *Grundfos Product Center*.

Examples

Maximum cable length

Example	
Allowed voltage drop (ΔU)	3 %
Motor	18.5 kW, MS6000, T40
Connection method	Direct-On-Line
Rated voltage (U)	3 × 400 V, 50 Hz
Rated current (I)	41.0 A
Rated power factor (cos φ)	0.82
Cable cross-section (q)	4 mm^2
Cable specific resistance (ρ)	0.025 [$\Omega.mm^2/m$]
Cable inductive resistance (X_L)	0.078×10^{-3}[Ω/m]
sin φ	0.57

$$L = \frac{400 \times 3}{41 \times 1.73 \times 100 \times \left(0.82 \times \frac{0.025}{4} + 0.57 \times 0.078 \times 10^{-3}\right)}$$

L = 128 m

Energy loss comparison

Example	
Motor	18.5 kW, MS6000, T40
Connection method	Direct-On-Line
Rated voltage (U)	3 × 400 V, 50 Hz
Rated current (I)	41.0 A
Cable length (L)	120 m
Cable specific resistance (ρ)	0.025 [$\Omega.mm^2/m$]
Operating hours/year	4000 h
Cable cross-section (q) options	
Choice A:	16 mm^2
Choice B:	25 mm^2

Choice A

$$\Delta p_A = \frac{3 \times 120 \times 0.025 \times 41^2}{16}$$

$$\Delta p_A = 946\,W$$

$Energy\ loss_A$ = 946W × 4000 h = 3782 kWh

Choice B

$$\Delta p_B = \frac{3 \times 120 \times 0.025 \times 41^2}{25}$$

$$\Delta p_B = 605\,W$$

$Energy\ loss_B$ = 605W × 4000 h = 2421 kWh

Savings

Annual savings	=	$Energy\ loss_A$ - $Energy\ loss_B$
	=	3782 kWh - 2421 kWh
	=	1361 kWh

By choosing the 25 mm^2 instead of the 16 mm^2 cable, an annual saving of 1361 kWh can be achieved. Considering an evaluation time of 10 years, the total energy saving can be:

Saving energy after 10 years = 1361 × 10 = 13610 kWh

The amount saved can be calculated in local currency by multiplying the saved energy by the local energy cost.

11. Further product documentation

MS - MMS Installation and operating instructions
MS - MMS Safety instructions and other important information
MS6000 Service Instruction
MS6000P Service Instruction
MS Service Kit Catalogue

12. Grundfos Product Center

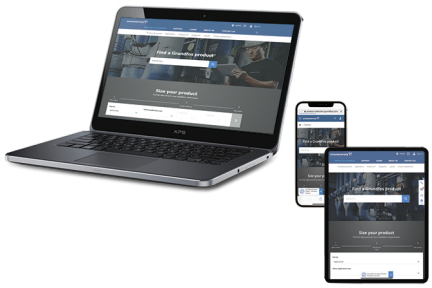
Online search and sizing tool to help you make the right choice.
From the international view, you can select your specific country to view the product range available to you.
International view: *http://product-selection.grundfos.com*

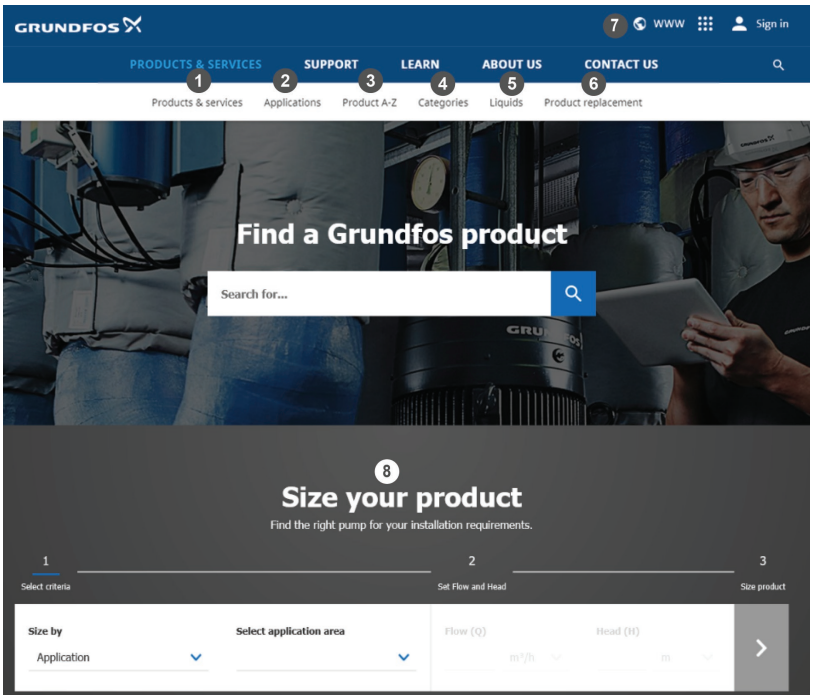
All the information you need in one place

Performance curves, technical specifications, pictures, dimensional drawings, motor curves, wiring diagrams, spare parts, service kits, 3D drawings, documents, system parts. The Product Center displays any recent and saved items - including complete projects - right on the main page.

Downloads

On the product pages, you can download installation and operating instructions, data booklets, service instructions, etc., in PDF format.





When you select your country, you will see the menus below. Note that some menus may not be available depending on the country.
Example: *https://product-selection.grundfos.com/uk*

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6	**Product replacement** enables you to find a suitable replacement.
7	**WWW** enables you to select the country, which changes the language, the available product range and the structure of the website.
8	**Sizing** enables you to size a product based on your application and operating conditions.

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