SPE

Regulated submersible pumps with PM motors

3000 rpm

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1. General description

SPE is a speed-controlled submersible pump system with a permanent magnet motor. It has a low running cost and can be used in changing operation conditions. The pump is suitable for a number of applications within groundwater pumping, for example the following:

- water supply
- irrigation
- groundwater lowering.

An all-stainless steel construction in three different material grades ensures that the pump can be used for both clean water as well as corrosive water.

The pump system consists of reliable hydraulics and an energy efficient IPM (Interior Permanent Magnet) type motor. The magnets are embedded in the rotor. The magnets in MS6000P are further protected as the rotor is hermetically sealed with a thin layer of metal. The motor design furthermore consists of the following:

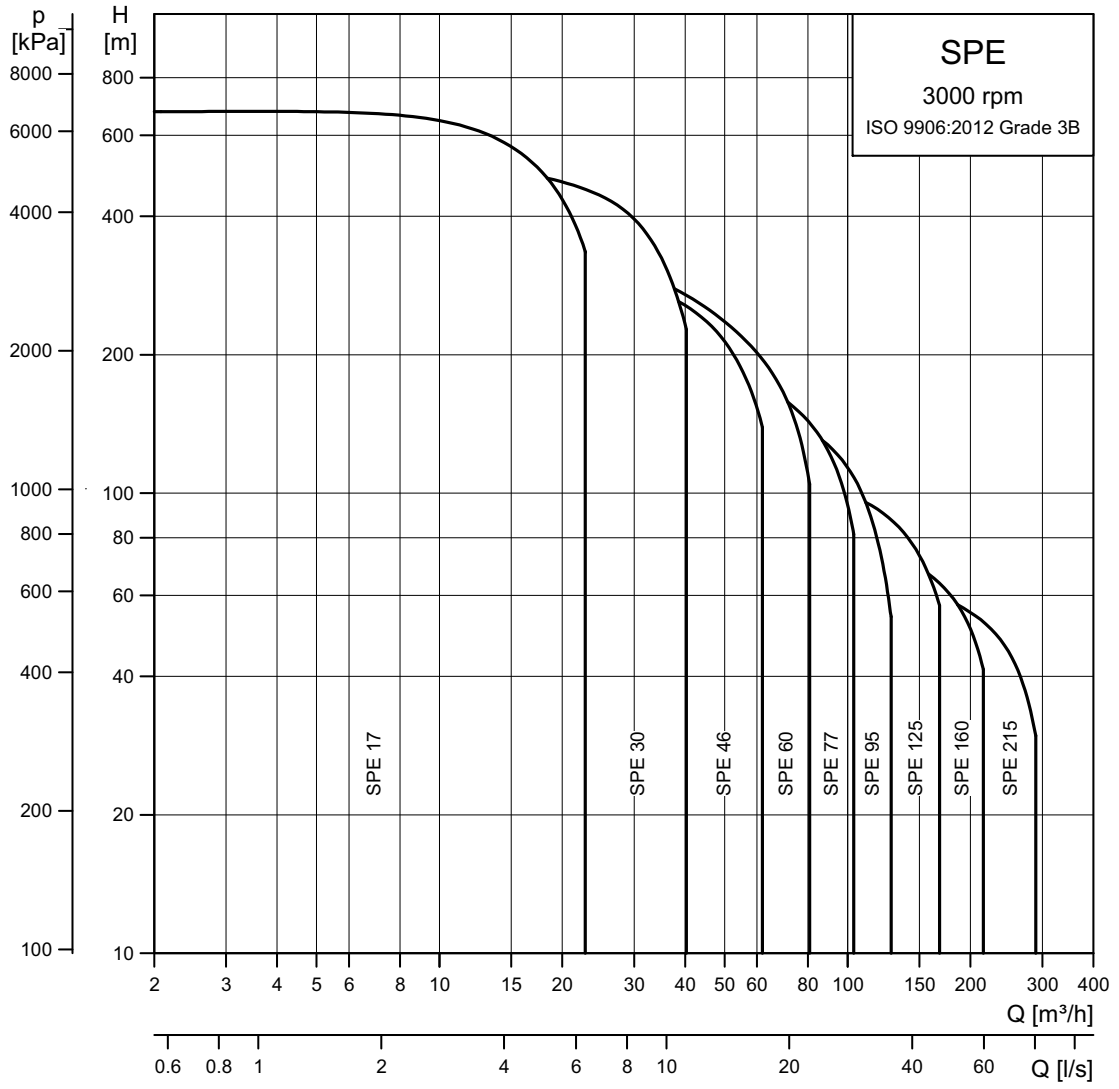
- canned stator design
- mechanical shaft seals with Silicon Carbide seal faces
- heavy duty thrust bearings.

The motor is running synchronous and needs a Variable Frequency Drive (VFD), such as the Grundfos CUE, to control the speed according to need. The CUE includes a wizard to make the setup easy. The CUE has the following predefined control modes:

- constant pressure
- constant flow
- constant level.

The CUE also features protection of the pump installation, including minimizing risk of water hammer and reducing stresses to the submersible motor during start by means of a soft starter function.

Performance range



ErP ready

The SPE pumps are energy-optimised and comply with the ErP Directive (Commission Regulation (EC) No 547/2012) which is in effect from 1 January 2013. From this date, all pumps are classified and graduated in a new energy efficiency index (MEI).

Minimum efficiency index

Minimum efficiency index (MEI) means the dimensionless scale unit for hydraulic pump efficiency at best efficiency point (BEP), part load (PL, 75 % BEP) and overload (OL, 110 % BEP). The Commission Regulation (EU) sets efficiency requirements to MEI ≥ 0.40 as from 1 January 2015. An indicative benchmark for best-performing water pump available on the market as from 1 January 2013 is determined in the Regulation.

- The benchmark for most efficient water pumps is MEI ≥ 0.70.
- The operation of the pump is efficient and economic as it is controlled by a variable frequency drive which enables the pump set to match varying performance requirements from the system.
- Information on benchmark efficiency is available at http://europump.eu/efficiencycharts.

Efficiency and MEI index for SPE pumps

Pump type	Pump size	Pump stage efficiency [%]	MEI
SPE 17	6"	74	≥ 0.70
SPE 30	6"	75	≥ 0.50
SPE 46	6"	76	≥ 0.40
SPE 60	6"	77	≥ 0.40
SPE 77	8"	78	N/A
SPE 95	8"	79	N/A
SPE 125	10"	79	N/A
SPE 160	10"	80	N/A
SPE 215	10"	83	N/A

Type key

Example of pump set	SPE 125	-4	N	Rp 6	6"	37 kW	D	3000 rpm

Type range (SPE)

Number of impellers

Stainless-steel parts of material

= EN 1.4301
N = EN 1.4401
R = EN 1.4539

Rubber parts of material

SPE 17- SPE 60	SPE 77- SPE 215
= LSR/NBR	= NBR
E = FKM	E = FKM

Connection

Rp thread (RpX)
R thread (RX)
NPT thread (XNPT)

Inlet motor size

Motor power [kW]

Number of motor cables

D = Single
= Double

rpm

Applications

SPE pumps are developed for pumping ground water from boreholes. The pumps are installed in boreholes or wells, submerged below the water level.

For industrial purposes, you can place the pump for example, in a tank.

The pumps are suitable for the following applications:

- raw-water supply
- irrigation
- groundwater lowering
- pressure boosting
- fountain applications
- mining applications.
- offshore applications.

Pump range

Type	Steel EN 1.4301	Steel (N) EN 1.4401	Steel (R) EN 1.4539	Connection[1)]
SPE 17	•	•	•	Rp 2 1/2 (R 3)
SPE 30	•	•	•	Rp 3 (R 3)
SPE 46	•	•	•	Rp 3 Rp 4 (R 4)
SPE 60	•	•	•	Rp 3 Rp 4 (R 4)
SPE 77	•	•	•	Rp 5
SPE 95	•	•	•	Rp 5
SPE 125	•	•	•	Rp 6
SPE 160	•	•	•	Rp 6
SPE 215	•	•	•	Rp 6

1) Figures in brackets ( ) indicate connection for pumps within a sleeve.

Motor range

MS6000P covers several standard motor outputs

Motor execution [kW]	7.5			18.5					30			45	
Motor output [kW]	4.0	5.5	7.5	9.2	11	13	15	18.5	22	26	30	37	45

2. Submersible pumps

Features and benefits

A wide pump range

Grundfos offers energy-efficient submersible SPE pumps ranging from 10 to 280 m^3/h. The pump range consists of pump sizes from SPE 17 to SPE 215. Each pump size is available with an optional number of stages to match a given duty point.

High pump efficiency

Often pump efficiency is a neglected factor compared to the price. However, it is important to notice that price variations are without importance to water supply economics compared to the importance of pump and motor efficiencies.

Example

If pumping 70 m^3/h at 100 m head for 10 years a normal pump set consumes approximately 2,775,000 kWh. By changing to an SPE high efficiency pump set the increased efficiency will result in a reduction of 274,200 kWh, corresponding to more than € 27,400 cost saving at a price of 0.10 €/kWh. In variable demand conditions the saving is even higher.

Material and pumped liquids

To ensure the right wear resistance and reduce the risk of corrosion, the pump ranges are available with the following steel variants:

- **SPE:** EN 1.4301
- **SPE N:** EN 1.4401
- **SPE R:** EN 1.4539

See specified material variants in *Pump range* on page 7.
For further protection in corrosive environments, a complete range of zinc anodes for cathodic protection is available. See page 60.

Rubber components

For pumping liquid with risk of chemical residue or liquids above 60 °C, all pumps can be supplied with rubber components made of FKM elastomer.

Low installation costs

Stainless steel sheet metal means low weight. This facilitates the handling of pumps and results in low equipment costs, reduced installation and service time.

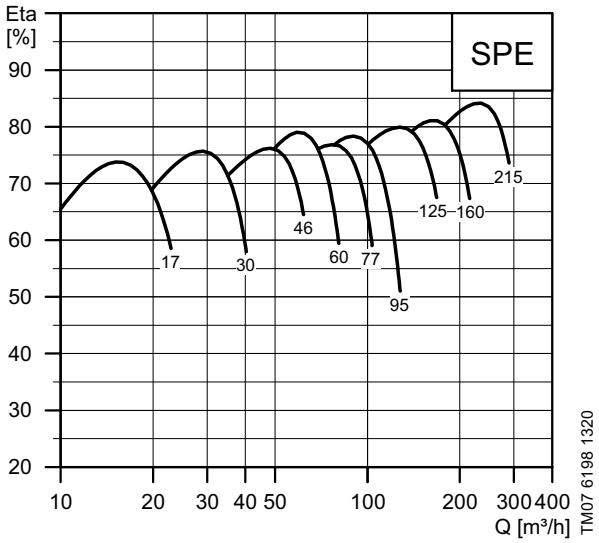


Fig. 1 Pump efficiencies in relation to flow

Fig. 2 Various SPE pumps

Bearings with sand channels

All bearings are water-lubricated and have an octagonal shape enabling sand particles to leave the pump together with the pumped liquid. The use of LSR ensures increased wear resistance, thus allowing a high limit for particles in the pumped liquid. LSR is used as standard in pumps ranging up to and including SPE 60. On SPE 77 and larger pumps the bearing material is NBR.

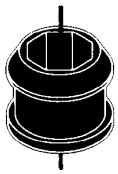


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Fig. 3 Bearing

Inlet strainer

The inlet strainer prevents particles over a certain size from entering the pump. The hole size is 4 x 20 mm.

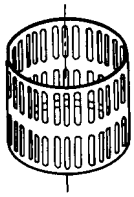

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Fig. 4 Inlet strainer

Non-return valve

All pumps have a non-return valve in the valve casing preventing backflow when the pump is stopped.

Due to the short closing time of the non-return valve the risk of water hammer is reduced to a minimum.

The valve casing is designed to have optimum hydraulic properties to minimise the pressure loss across the valve and thus to contribute to the high efficiency of the pump.

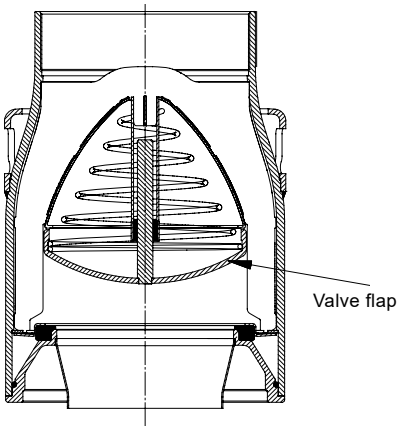

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Fig. 5 Non-return valve

Stop ring

The stop ring prevents damage to the pump during transport and in case of upthrust during pump startup.

The stop ring, which is designed as a thrust bearing, limits axial movements of the pump shaft.

The stationary part of the stop ring (A) is secured in the upper chamber.

The rotating part (B) is fitted above the split cone (C).

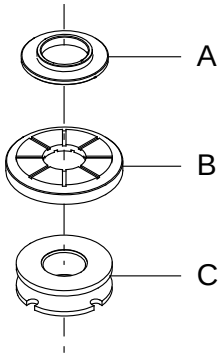

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Fig. 6 Stop ring (rotating and stationary parts).

Pump functioning as turbine

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

Material specification (SPE 17 - SPE 60)

Pos.	Component	Material	Standard	N-version	R-version
			EN		
1	Valve casing	Stainless steel	1.4301	1.4401	1.4517
2	Valve cup	Stainless steel	1.4301	1.4401	1.4539
	Valve seat	NBR-FKM	NBR-FKM	NBR-FKM	NBR-FKM
7	Neck ring	NBR-FKM	NBR-FKM	NBR-FKM	NBR-FKM
8	Bearing	NBR-FKM-LSR	NBR-FKM-LSR	NBR-FKM-LSR	NBR-FKM-LSR
8a	Washer for stop ring	Carbon/graphite HY22 in PTFE mass			
9	Chamber	Stainless steel	1.4301	1.4401	1.4539
13	Impeller	Stainless steel	1.4301	1.4401	1.4539
14	Suction interconnector	Cast stainless steel	1.4308	1.4408	1.4517
	Strainer	Stainless steel	1.4301	1.4401	1.4539
16	Shaft complete	Stainless steel	1.4057	1.4460	1.4462
17	Strap	Stainless steel	1.4301	1.4401	1.4539
18	Cable guard	Stainless steel	1.4301	1.4401	1.4539

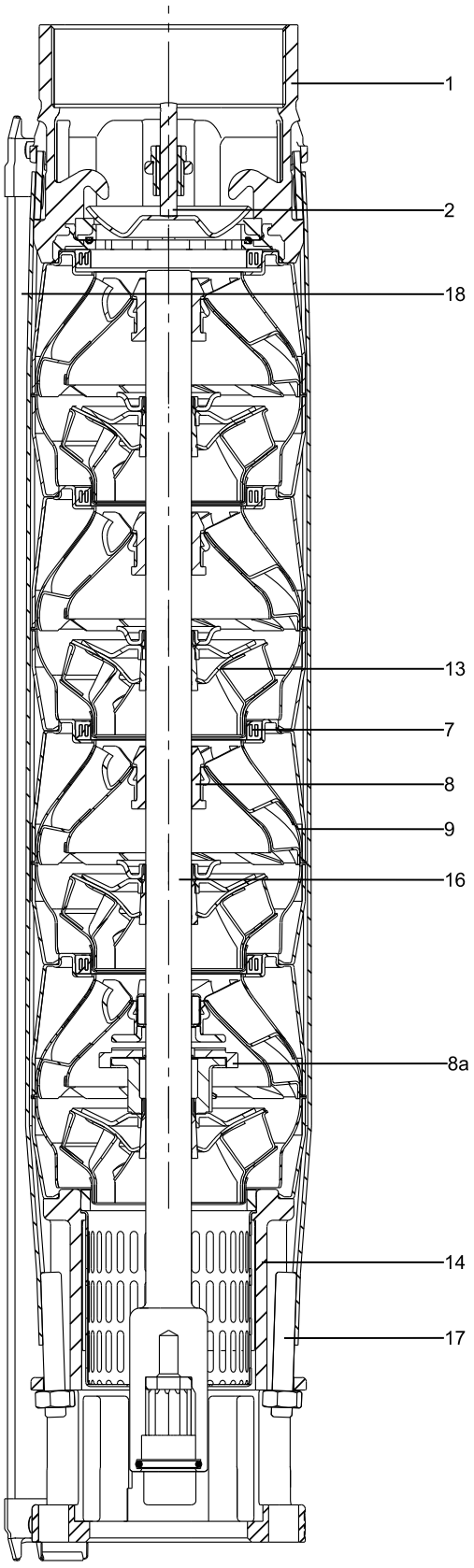

Fig. 7 Example SPE 46

Material specification (SPE 77 - SPE 215)

Pos.	Component	Material	Standard	N-version	R-version
			EN		
1	Valve casing	Stainless steel	1.4301	1.4401	1.4539
2	Valve cup	Stainless steel	1.4301	1.4401	1.4539
	Valve seat	NBR-FKM	NBR-FKM	NBR-FKM	NBR-FKM
7	Neck ring	NBR-FKM	NBR-FKM	NBR-FKM	NBR-FKM
8	Bearing	NBR-FKM	NBR-FKM	NBR-FKM	NBR-FKM
	Washer for stop ring	Carbon/graphite HY22 in PTFE mass			
9	Chamber	Stainless steel	1.4301	1.4401	1.4539
13	Impeller	Stainless steel	1.4301	1.4401	1.4539
14	Suction interconnector	Cast stainless steel	1.4308	1.4408	1.4517
	Strainer	Stainless steel	1.4301	1.4401	1.4539
16	Shaft complete	Stainless steel	1.4057	1.4460	1.4462
17	Strap	Stainless steel	1.4301	1.4401	1.4539
18	Cable guard	Stainless steel	1.4301	1.4401	1.4539

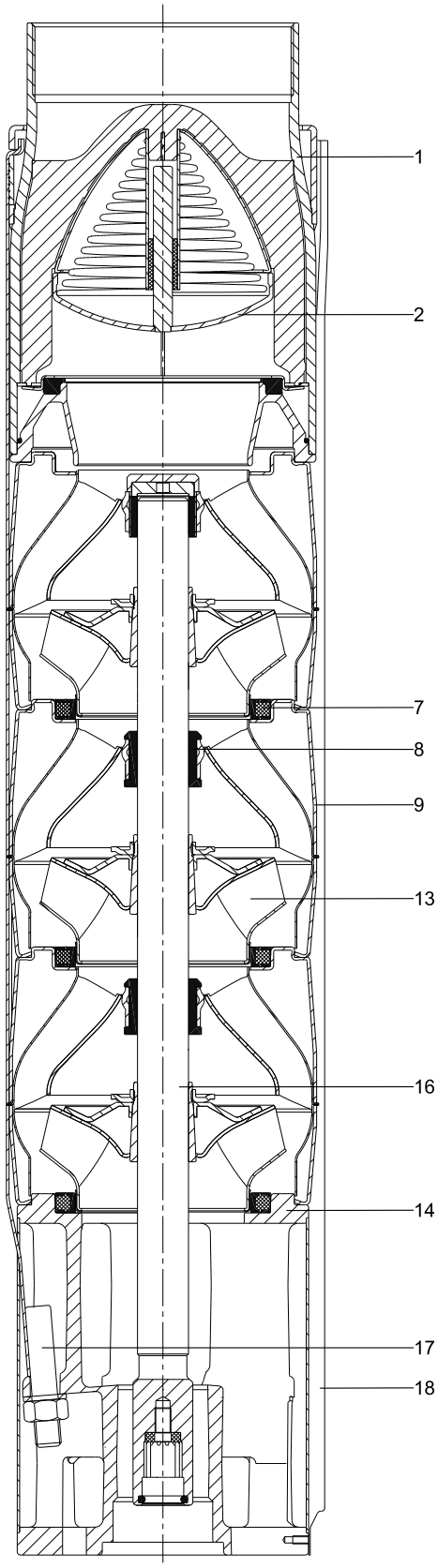

Fig. 8 Example SPE 77

3. Submersible permanent magnet motors

For further information about Grundfos MS6000P submersible motors, see the MS motor literature available in Grundfos Product Center at https://product-selection.grundfos.com.

Features and benefits

Grundfos offers a complete range of 6 inch submersible motors of IPM (Interior Permanent Magnet) design, named MS6000P. These are based on the Grundfos MS6000 motor platform including the mechanical construction, thrust bearings with high thrust capability and shaft seals. The permanent magnet motor is a 4-pole synchronous motor, requiring a variable frequency drive as it cannot be directly connected to the electricity grid, contrary to the asynchronous motor.

The MS6000P permanent magnet motor offers the following advantages:

- 8-10 % higher efficiency compared to an asynchronous motor with the same output power.
- More compact design due to the high energy density of the permanent magnets, thus offering a lighter motor with a higher output.
- Reduced internal temperature in the motor, due to the high efficiency
- Strong permanent magnets. The Grundfos 6 inch version is based on 20 years of operating experience with a similar design.

The MS6000P is available in T60 version only. This means that the motor is able to operate in applications up to 60 °C as long as a standard cooling flow of 0.15 m/s is ensured. In most applications the media temperature is less than 60 °C and the surplus temperature capacity ensures an even more robust motor.

For particularly demanding applications in corrosive media MS6000P is available in stainless steel quality 1.4539, called R version. Typical applications are the following:

- Mining dewatering
- Fish farming
- Offshore industrial applications

Fig. 9 MS6000P motors

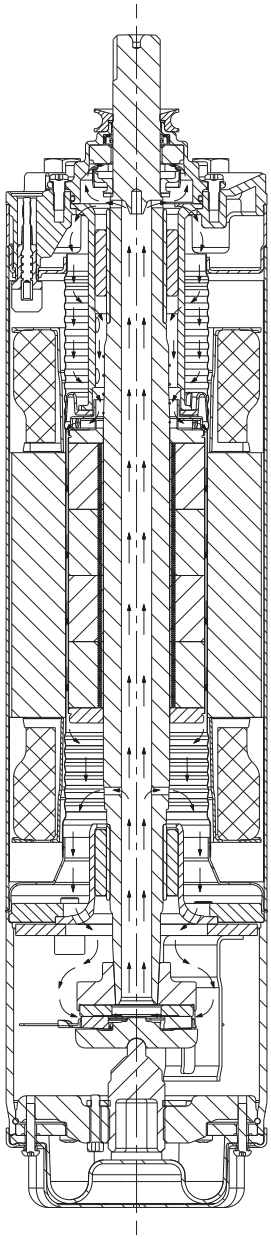

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Fig. 10 MS6000P lubrication flow

Stator

Grundfos MS6000P consists of a hermetically sealed stator withstanding external pressure up to 30 bar. It is a 4-pole construction with insulation class F winding material. All surfaces in contact with the pump media are mad of stainless steel. The following material grades are available:

- EN1.4301 for non-demanding installations (approved for drinking water).
- EN1.4539 for installations with high chloride content. The stator is filled with an epoxy filler and wound for high robustness using grade two, over coated enamel winding wire.

Shaft and rotor

The NEMA splined shaft extension is friction welded to a stainless steel shaft. Stainless steel radial bearing bushes on the shaft form the rotating part of the radial bearings. Stationary part of the radial bearing is a carbon or graphite bush. The rotor pack consists of indexed segments with integrated (buried) rare earth magnets placed as a 4-pole construction. This makes the motor an IPM type. The rotor pack is hermetically sealed by a metal cladding welded onto the shaft. This ensures a long life time and prevents corrosion of the magnets. The bottom of the shaft has the rotating part of the thrust bearing mounted and the entire shaft is gun drilled in order to ensure lubrication of the mechanical shaft seal and the radial bearings. Due to the use of permanent magnets no heat is generated in the rotor pack and subsequently the temperature rise in the motor liquid will decrease drastically. This benefits the life time of the construction and ensures more robust lubrication film in the radial and thrust bearing.

Thrust bearing

Grundfos MS6000P uses identical thrust bearing to the MS6000 series consisting of a ceramic rotating disc running against tilting pads and carbon or graphite shoes on the stationary part.

Shaft seal system

Grundfos MS6000P has a rubber sand slinger covering the top of an stainless steel shaft sealing house. When the shaft starts rotating, settled sand is removed from the shaft seal area due to the centrifugal force.

Inside the shaft seal house a lip seal is placed above a mechanical shaft seal with SIC/SIC faces placed in NBR rubber elastomers. The shaft seal construction enables drinking water approval of the finished product.

The shaft seal is according to EN 12756.

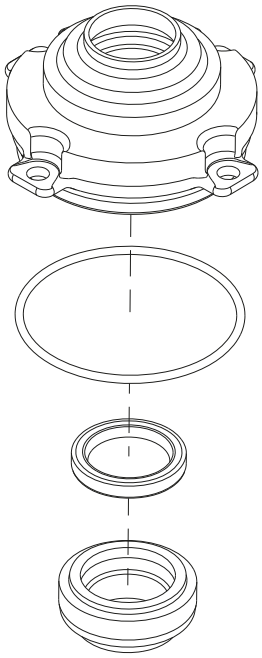

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Fig. 11 Shaft seal, MS6000P

Lightning protection

Grundfos recommends to use extra lightning protection or surge arrestor for the electrical panels in relation to the SPE system.

Material specification for MS6000P

Standard version motor

Pos.	Component	Material
1	Shaft	EN 1.4057
2	Shaft seal	SiC/SiC
	Rubber type	NBR
3	Motor sleeve	EN 1.4301
4	Motor end shield	EN 1.4301
	Diaphragm	NBR
5	Radial bearing	Carbon/stainless steel
6	Axial bearing	Ceramic/carbon

R-version motor

Pos.	Component	Material
1	Shaft	EN 1.4462
2	Shaft seal	SiC/SiC
	Rubber type	FKM
3	Motor sleeve	EN 1.4539
4	Motor end shield	EN 1.4539
	Diaphragm	FKM
5	Radial bearing	Carbon/stainless steel
6	Thrust bearing	Ceramic/carbon

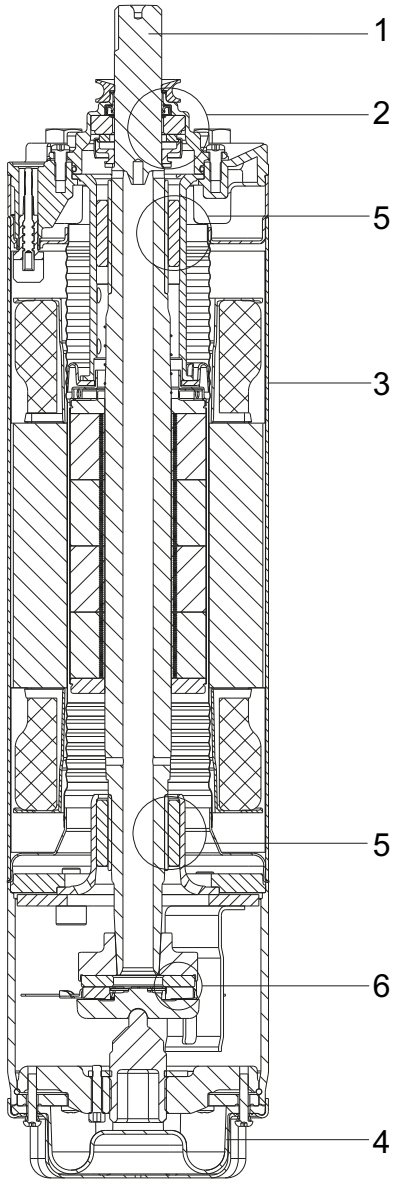

Fig. 12 MS6000P

4. Grundfos variable frequency drive for SPE

In order to operate the SPE pump a variable frequency drive is required. Grundfos offers the CUE for this purpose.

For use in solar application Grundfos recommends RSI. For further information about Grundfos RSI and Solar, see the literature available in Grundfos Product Center at https://product-selection.grundfos.com.

CUE variable frequency drive

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Fig. 13 The CUE range

Grundfos CUE is a series of external variable frequency drives designed for speed control of a wide range of Grundfos pumps, including SPE.

When a CUE is installed, the motor requires no further overload protection.

Pt100 or Pt1000 together with MCB 114 sensor input module can provide overheating protection of motor windings if needed.

CUE offers quick and easy setup and commissioning compared to a standard variable frequency drive as the startup guide is designed specifically for Grundfos pumps, including SPE.

Overview of the relevant CUE range for SPE

Supply voltage [V]	Power range [kW]				
	4.0	7.5	11	45	75
3 x 380-500	•	•	•	•	•
3 x 525-600	•	•			
3 x 525-690			•	•	•

CUE is available in the following enclosure classes:

- IP20/21
- IP54/55.

RFI filters

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

Voltage [V]	Typical shaft power, P2 [kW]	RFI filter type	Application
3 x 380-500	4.0 - 90	C1	Domestic
3 x 525-600	4.0 - 7.5	C3	Industry
3 x 525-690	11-25	C3	

Functions

CUE has a wide range of pump-specific functions. For groundwater applications the following are especially relevant:

- constant pressure
- constant level
- constant flow rate.

CUE features

- Startup guide
- Easy setup based on the pump type
- Check of direction of rotation
- Duty and standby operation
- Dry-running protection
- Low-flow stop function.

The CUE startup guide, is automatically activated at the first startup. Here, a number of parameters are set automatically on the basis of the pump type. Other parameters are set manually on the basis of the data on the motor and pump nameplates. The startup guide can be repeated, if necessary.

Thanks to the startup guide, the installer can quickly set central parameters and put CUE into operation.

Sensors

The following sensors can be used in connection with CUE:

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

All sensors are with 4-20 mA output signal.

Sine-wave filter

The use of IPM-ready sine-wave filters is required on SPE pumps.

The purpose of output filters is the following:

- Protect the motor from overvoltage and increased operating temperature.
- Reduce voltage stress on the motor windings and stress on the motor insulation system.
- Decrease acoustic noise from the motor that is driven by a variable frequency drive.

Sine-wave filters have a particularly high degree of filtering, resulting in high reduction of motor insulation stress and elimination of switching acoustic noise from the motor. The motor losses are reduced as the motor is fed with a sine-wave voltage and because the filter eliminates the pulse reflections in the motor cable.

Sine wave filter selection

Filters used with SPE must be selected according to motor current and filter rating at 100 Hz(3000 RPM).

Part number	Enclo-sure degree	Minimum switching frequency	Filter current rating at 200-500 V and motor frequency[1)]			
			50 Hz	60 Hz	100 Hz	120 Hz
		[kHz]	[A]	[A]	[A]	[A]
96754976	**IP20**	5	17	16	13	12
96754977	**IP20**	4	24	23	18	17
96754978	**IP20**	4	38	36	26.5	24
96755019	**IP20**	4	48	45.5	36	34
96755021	**IP20**	3	62	59	46.5	44
96755032	**IP20**	3	75	71	56	53
97774436	**IP23**	3	115	109	86	72
97775142	**IP23**	3	180	170	135	112

1) Max ambient temperature 45 °C

Cables in CUE installations

When CUE is used with SPE pumps, Grundfos distinguishes between two types of installation:

- installation in EMC-insensitive sites. See fig. 14.
- installation in EMC-sensitive sites. See fig. 15.

The two types of installation are different when it comes to the use of screened cable.

Note: Drop cables are always unscreened.

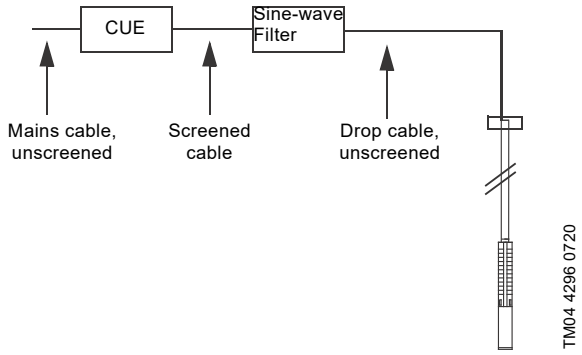


Fig. 14 Example of normal installation

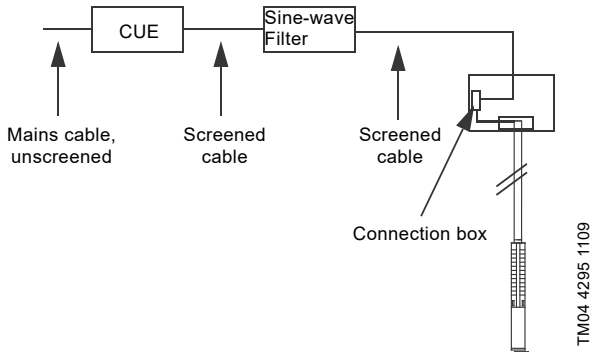


Fig. 15 Example of installation in EMC-sensitive sites

Screened cables are required in parts of the installation where the surroundings must be protected against EMC.

CUE is the right choice of variable frequency drive in SPE installations as it meets all basic issues.

CUE has a pre-installed startup guide which takes the installer through all the necessary settings.

The table below shows the different issues to be considered when using variable frequency drive in SPE installations.

Issues	Explanation
Ramp (up and down): Maximum 3 seconds.	The journal bearings must be lubricated in order to limit wear and overheating of windings.
Temperature monitoring by a Pt sensor.	Overheating of the motor leads to low insulation resistance which is sensitive to voltage peaks. Tempcon sensors do not work with variable frequency drive operation.
Reduce peak voltages (maximum 800 V peaks).	Never exceed peak voltages of 850 V at motor leads.
Remember output filter.	Cables act as an amplifier therefore measure peaks at the motor.
Rise time (dU/dt) must be limited to a maximum of 1000 V/µs. It is determined by the equipment in CUE.	As the time between switches is an expression of losses, the limit of 1000 V/µs can be exceeded. The solution is not higher insulation of the motor, but filter in the output from CUE.
Constant operation at minimum 55 Hz.	Too low speed results in low flow and thereby poor lubrication of journal bearings.
Size CUE in respect of the current, not the power output.	Can end up with a too small CUE.
Size cooling provision for stator tube at duty point with lowest flow rate.	Flow minimum m/s along the stator housing must be considered.
Ensure that the pump is used within the range of the pump curve.	Focus on outlet pressure and sufficient Net Positive Suction Head, as vibrations can damage or destroy the motor.

Using variable frequency drives of other brands.

The following parameters are relevant when using variable frequency drives of other brands.

Data for 100 Hz / 3x380 V motor voltage

	Power range [kW]			
	7.5	**18.5**	**30**	**45**
PM back EMF at 100 Hz [V]	266	260	270	246
PM d-axis inductance (Ld) [mH]	11.0	4.6	3.4	2.1
PM q-axis inductance (Lq) [mH]	26.4	11.7	8.0	5.5
PM type designation	IPM			
Frequency [Hz]	100			
Number of poles	4			

Grundfos offering, easy selection

MS6000P			CUE (100 Hz)			Sine wave filter (100 Hz)		Motor cable
Motor voltage 3 x 350 V (3000 RPM)			3 x 380-440 V			3 x 200-500 V		
Part number	Output [kW]	Current [A]	Part number	Output [kW]	Current [A]	Part number	Current [A]	Part number
76207712	4.0	9.6	99616713	4.0	10	96754976	13	96164209[1)]
	5.5	12.6	99616714	5.5	13			
	7.5	16.6	99616716	11	24	96754977	18	
76207717	9.2	21.4				96754978	26.5	
	11	25.0	99616717	15	32			
	13	29.2				96755019	36	
	15	33.4	99616718	18.5	37.5			
	18.5	40.6	99616719	22	44	96755021	46.5	
76207720	22	46.2	99616720	30	61	96755032	56	96164214[2)]
	26	54.0						
	30	61.8	99616721	37	73	97774436	86	
76207722	37	85.6	99616722	45	90	97775142	135	2 x 96164215[3)]
	45	103.0	99616723	55	106			

1) 96164209: 4 G 6.0 mm^2 (5 m)
2) 96164214: 4 G 10 mm^2 (5 m)
3) 96164215: 4 G 10 mm^2 (10 m)

5. Selection and sizing

Grundfos Product Center can calculate the exact duty point and energy consumption.

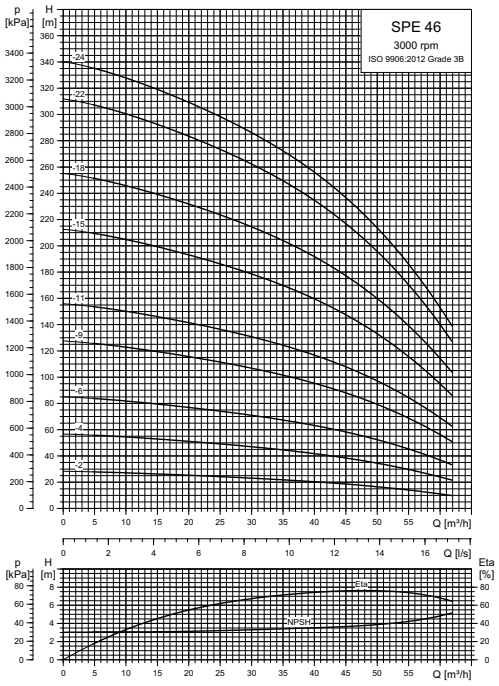
For further information see *Grundfos Product Center* at: https://product-selection.grundfos.com

Select the pump based on the following parameters:

- the duty point of the pump (see below)
- friction loss in the pipes, pump efficiency (see below)
- pump materials (see page 10)
- pump connections (see page 26)

Duty point of the pump

With the help of a duty point, it is possible to select a pump on the basis of the curve charts in section *Performance curves and technical data*, page 33.



TM07 6153 2013

Fig. 16 Example of a curve chart

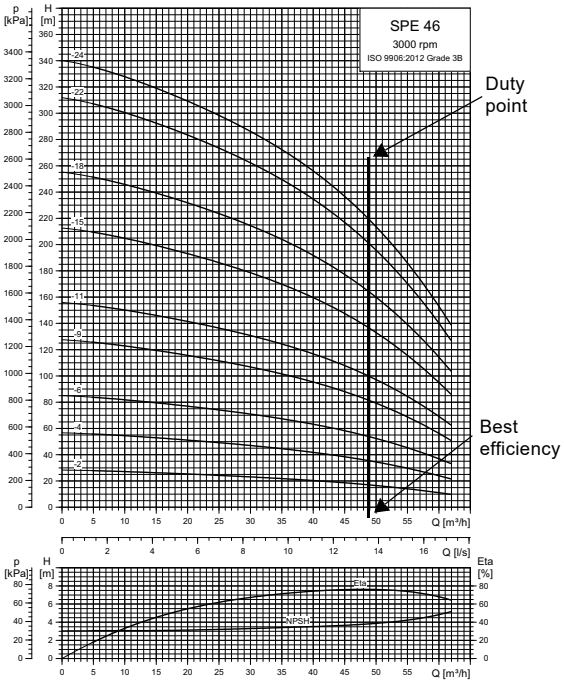
Dimensional data

When sizing a pump, take the following parameters into account:

- required flow and pressure at the draw-off point
- friction loss in the pipes (H_f)
- pressure loss in for example, long pipes, bends, valves
- best efficiency at the estimated duty point
- NPSH value.
  For calculation of the NPSH value, see *Grundfos Product Center* or *Cavitation*, page 25.

Pump efficiency

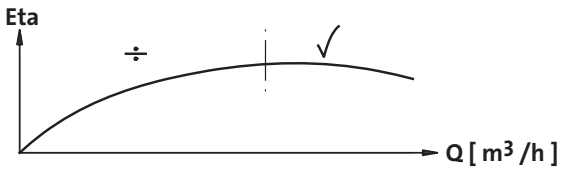
Before determining the best efficiency point, identify the operation pattern of the pump. If the pump is expected to operate at the same duty point, select a pump which operates at a duty point corresponding to the best efficiency of the pump.



TM07 6153 2013

Fig. 17 Example of an SPE pump's duty point

As the pump is sized on the basis of the highest possible flow, it is important always to have the duty point to the right on the efficiency curve (Eta) in order to keep the efficiency high when the flow drops.



TM00 9190 1303

Fig. 18 Best efficiency

E-pumps are used in applications characterised by a variable flow. Consequently, it is not possible to select a pump that is constantly operating at optimum efficiency.

In order to achieve optimum operating economy, select the pump based on the following criteria:

- The maximum duty point required must be as close as possible to the QH curve of the pump.
- The flow rate at the duty point required must be close to the optimum efficiency (Eta) for most operating hours.

Between the minimum and maximum performance curves, E-pumps have an large number of performance curves, each representing a specific speed. Therefore, it may not be possible to select a duty point close to the Max. curve.

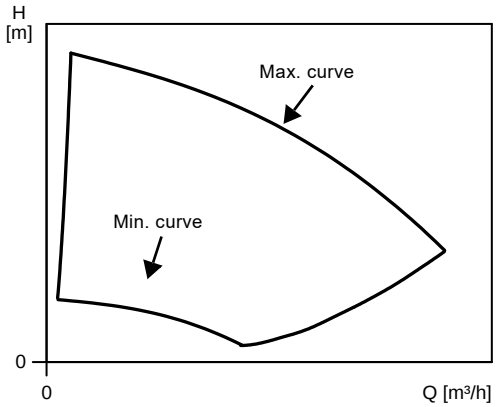


Fig. 19 Min. and max. performance curves

In situations where it is not possible to select a duty point close to the Max. curve, the below affinity equations can be used. The following are the appropriate variables for the motor speed (n):

- head (H)
- flow (Q)
- input power (P).

The approximated formulas only apply when the system characteristic remains unchanged for n_n and n_x and when it is based on the formula $H = k \times Q^2$ where k is a constant.

The power equation implies that the pump efficiency is unchanged at the two speeds. In practice, this is an acceptable approximation.

To obtain a precise calculation of the power savings resulting from a reduction of pump speed, the efficiencies of the variable frequency drive and the motor must be taken into account.

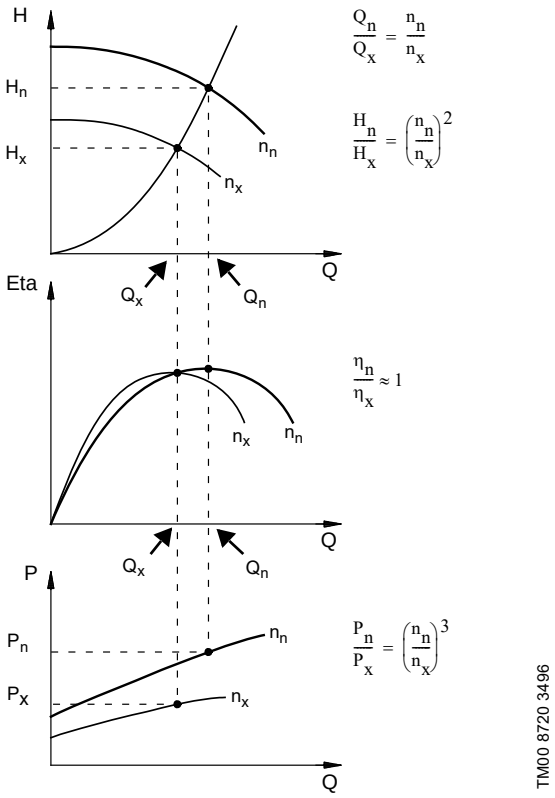


Fig. 20 Affinity equations

H_n Rated head [m]

H_x Actual head [m]

Q_n Rated flow rate [m^3/h]

Q_x Actual flow rate [m^3/h]

P_n Rated input power [kW]

P_x Actual input power [kW]

n_n Rated motor speed [min^{-1}] (n_n = 3000 min^{-1})

n_x Actual motor speed [min^{-1}]

η_n Rated efficiency [%]

η_x Actual efficiency [%]

See *Grundfos Product Center* for further information at https://product-selection.grundfos.com.

6. Operating conditions

To ensure long and trouble-free pump life, it is important that the following is observed.

Inlet pressure

The minimum inlet pressure is indicated by the NPSH-curves in the single-stage curve charts.

The minimum safety margin of the NPSH-curves must always be 0.5 m head.

Minimum flow rate

To ensure sufficient cooling of the motor, the pump must not run continuously at a flow rate below 0.1 x nominal flow rate.

Operation of the pump against a closed valve must be limited to a maximum of 30 seconds due to the risk of local heating of the pumped liquid and the consequent damage to the pump and motor.

Maximum flow rate

The pump must not run continuously at a flow rate above 1.3 x nominal flow rate due to the risk of upthrust and cavitation.

Pumped liquids

SPE pumps are capable of pumping clean, thin, non-aggressive liquids, not containing solid particles or fibres larger than sand grains.

Pump type	Maximum content of sand [ppm]
SPE 17 - SPE 60	100
SPE 77 - SPE 215	50

Special liquids

A larger content of sand will reduce pump life.

The following versions are available for applications involving aggressive liquids:

- SPE-N made of stainless steel EN 1.4401
- SPE-R made of stainless steel EN 1.4539.

Pumping of liquids with a higher density than that of water requires a motor with a correspondingly higher output.

Pumping of liquids with a higher viscosity than that of water may result in the following:

- increased pressure loss
- reduced hydraulic performance
- increased pump power input.

In case of doubt, contact Grundfos.

Liquid temperature

For protection of pump and motor rubber parts, the liquid temperature must not exceed 60 °C.

Maximum liquid temperature

The maximum liquid temperature of 60 °C requires a flow velocity of the liquid past the motor of 0.15 m/s.

Maximum operating pressure

Maximum operating pressure is 3 MPa (30 bar).

Ramp times

Maximum 3 s for start 0 - 55 Hz and for stop 55 - 0 Hz.

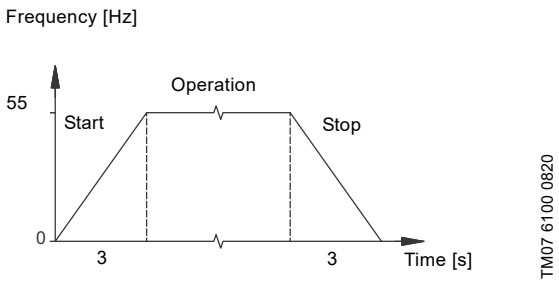


Fig. 21 Ramp times

Service

If requesting Grundfos to service the pump, contact Grundfos with details about the pumped liquid before returning the pump for service. Otherwise Grundfos can refuse to accept the pump for service. Possible costs of returning the pump are paid by the customer.

Any application for service, no matter to whom it may be made, must include details about the pumped liquid if the pump was used for liquids which are harmful to health or toxic.

Before returning a pump, it must be cleaned in the best possible way.

Important: Make sure to mention that it is a permanent magnet motor.

Pump functioning as turbine

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

Start/stop

The SPE pump is suitable for continuous as well as intermittent operation.

- Minimum one start per year is recommended
- Maximum 120 per hour.
- Maximum 360 per day.
- If a switch or a sensor is used to start and stop the pump set, the signal has to be connected correctly to the variable frequency drive.
- The variable frequency drive is allowed to be disconnected from the mains maximum two times per minute.

Sound pressure level

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

Sound pressure level of pumps

The values apply to pumps submerged in water without an external regulating valve.

Pump type	$\overline{L}_{pA}$ [dB(A)]
SPE 17	< 70
SPE 30	< 70
SPE 46	< 70
SPE 60	< 70
SPE 77	< 70
SPE 95	< 70
SPE 125	79
SPE 160	79
SPE 215	82

Sound pressure level of motors

The sound pressure level of Grundfos MS6000P motors is lower than 70 dB(A).

Moment of inertia

Calculate the moment of inertia by using one of the formulas below. Choose the formula according to the pump type and insert the number of stages.

Pump type	Moment of inertia [kgm^2]
SPE 17	$(4.0 + n \times 2.0) \times 10^{-4}$
SPE 30	$(4.0 + n \times 5.1) \times 10^{-4}$
SPE 46	$(4.0 + n \times 3.6) \times 10^{-4}$
SPE 60	$(4.0 + n \times 4.1) \times 10^{-4}$
SPE 77	$(5.5 + n \times 19) \times 10^{-4}$
SPE 95	$(5.5 + n \times 22) \times 10^{-4}$
SPE 125	$(5.5 + n \times 33) \times 10^{-4}$
SPE 160	$(5.5 + n \times 33) \times 10^{-4}$
SPE 215	$(25 + n \times 100) \times 10^{-4}$

n = number of stages.

Recommended minimum borehole diameter

If you use a connecting piece in the installation, the recommended minimum borehole diameter is the largest diameter of either pump or connecting piece.

The following table shows the recommended minimum borehole diameter of SPE pumps with standard connections.

Pumps size	Number of cables	Sleeve	Minimum borehole diameter [mm]				
			Rp 2 1/2"	Rp 3"	Rp 4"	Rp 5"	Rp 6"
SPE 17 / SPE 30	1	-	147	147	-	-	-
		●	-	180	-	-	-
	2	●	-	186	-	-	-
SPE 46 / SPE 60	1	-	-	153	153	-	-
	2	-	-	156	156	-	-
SPE 77 / SPE 95	1	-	-	-	183	183	-
	2	-	-	-	191	191	-
SPE 125 / SPE 160	1	-	-	-	-	216	216
	2	-	-	-	-	220	220
SPE 215	1	-	-	-	-	-	241
	2	-	-	-	-	-	244

How to read the curve charts

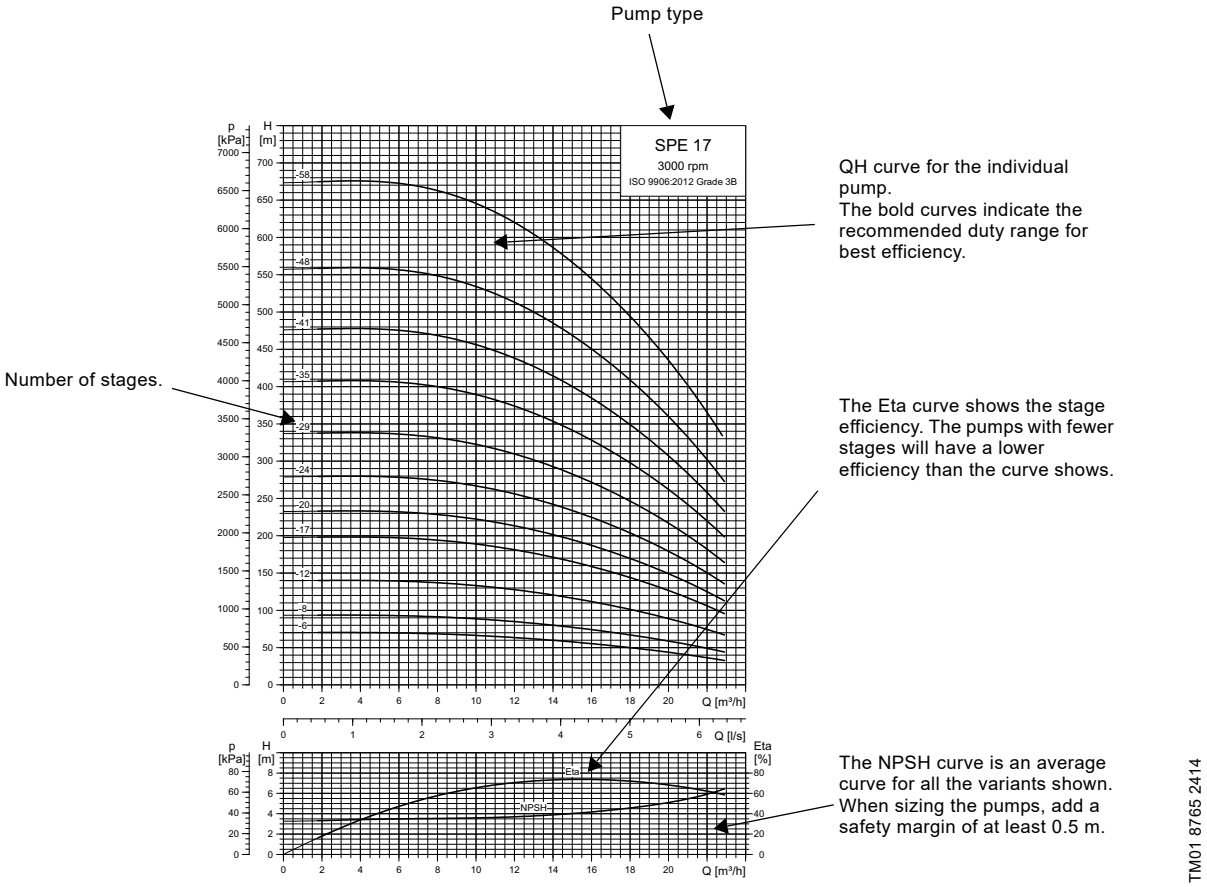


Fig. 22 How to read the curve charts

Curve conditions

The conditions below apply to the curves on pages 26 to 52.

General conditions

- Curve tolerances according to ISO 9906:2012 - Grade 3B.
- The performance curves show pump performance at n = 3000 min^{-1}.
- The measurements were made with airless water at a temperature of 20 °C. The curves apply to a kinematic viscosity of 1 mm^2/s (1 cSt). When pumping liquids with a density higher than that of water, use motors with correspondingly higher outputs.
- The bold curves indicate the recommended performance range.
- The performance curves include possible losses such as non-return valve loss.

Curves

- **Q/H:** The curves include valve and inlet losses at the actual speed.
  Operations without a non-return valve increase the actual head at rated performance by 0.5 to 1.0 m.
- **NPSH:** The curve includes pressure loss in the suction interconnector and shows the required inlet pressure.
- **Power curve:** P2 shows the pump power input of each stage for the individual pump size when the pump is running at the rated speed.
- **Efficiency curve:** Eta shows pump stage efficiency. If Eta for the actual pump size is needed, consult Grundfos or visit Grundfos Product Center https://product-selection.grundfos.com.

Certificates

For more information about SPE certificates, see *Certificates* on page 61.

Cavitation

Cavitation does not normally take place in submersible pumps. If the following two factors occur at the same time, cavitational damage on both pump and motor can occur at low installation depths:

– Invasive air bubbles
– Reduction of counter pressure caused for instance, by pipe fracture, severe corrosion of riser main and extremely high consumption.

To calculate the required installation depth to prevent cavitation, the following formula is applied:

$H = H_b - NPSH - H_{loss} - H_v - H_s$

H_b = barometric pressure
NPSH = Net Positive Suction Head
H_{loss} = pressure loss in suction pipe
H_v = vapour pressure
H_s = safety factor

When the formula gives a positive H value, the pump is able to operate at suction lift. In that case, the standard indication of minimum installation depth is valid.

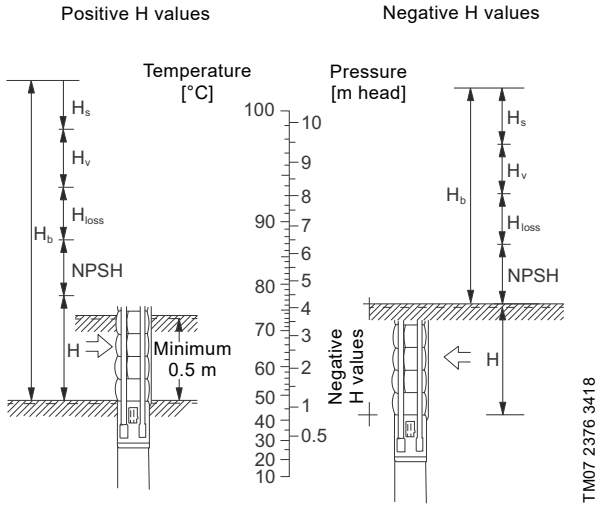


Fig. 23 Installation depth

Example:

An SPE 60 at a flow of 78 m^3/h.

H_b	10.0 m
NPSH from data sheet	4.2 m
H_{loss}	0.0 m
H_v at 32 °C	0.5 m
H_s	1.0 m

H = 10 - 4.2 - 0 - 0.5 - 1.0 = 4.3 m

As H is positive, the pump is able to create a vacuum of 0.43 bar without being damaged and no special precautions have to be taken. In case of corrosion of the riser main resulting in a 20 mm hole, there is no counter pressure and the pump flow increases to more than 90 m^3/h.

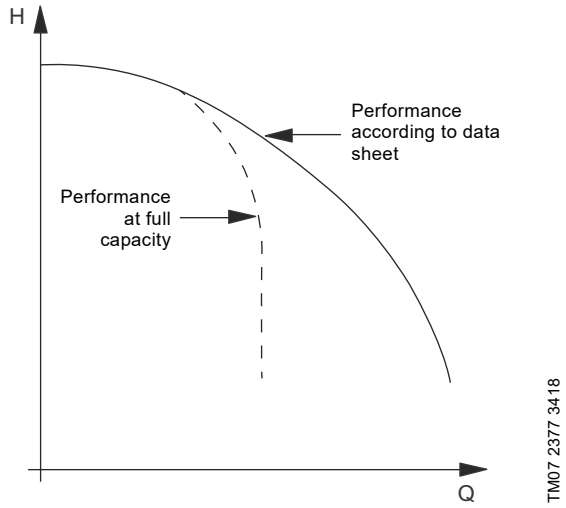
H_b is unchanged	10.0 m
NPSH will increase to	8.0 m
H_{loss}	0.0 m
H_v will increase due to recirculation in well to	4.6 m
H_s is unchanged	1.0 m

This will give

H = 10 - 8 - 0 - 4.6 - 1.0 = -3.6 m

This value of H means that the pump inlet must be at least 3.6 m below the dynamic water level, otherwise the pump cavitates.

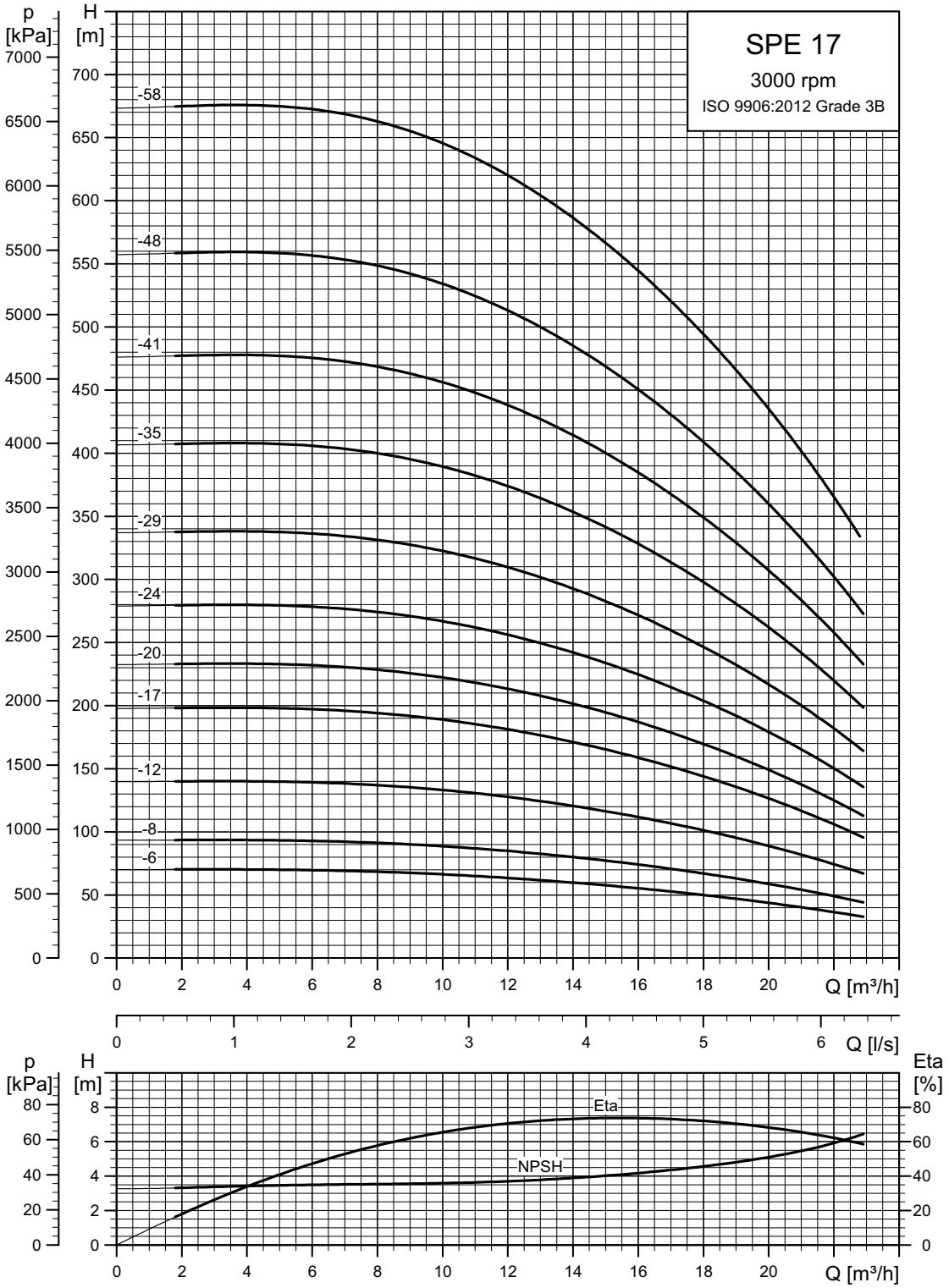
When a pump cavitates, it does not give full performance, see figure below.



7. Performance curves and technical data

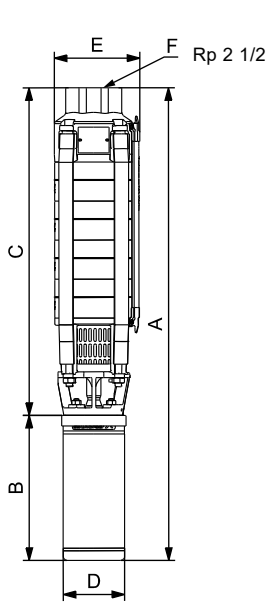
SPE 17

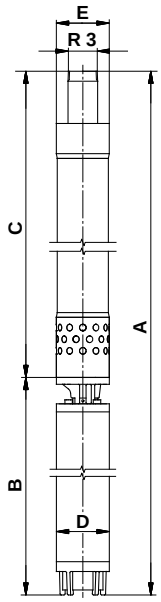
Performance curves



See also section *How to read the curve charts* on page 24.

Dimensions and weights





TM06 5397 0818 - TM01 4197 4118

Pump type	Motor Power [kW]	Dimensions [mm]					Net weight [kg]
		C	B	A	D	E	
SPE 17-6	4.0	644	547	1191	139.5	142	45.6
SPE 17-8	5.5	765	547	1312	139.5	142	48.3
SPE 17-12	7.5	1007	547	1554	139.5	142	53.8
SPE 17-17	11	1309	667	1977	139.5	142	73.6
SPE 17-20	13	1507	667	2174	139.5	142	77.8
SPE 17-24	15	1749	667	2416	139.5	142	83.2
SPE 17-29	18.5	2052	667	2719	139.5	142	90.1
SPE 17-35	22	2415	817	3232	139.5	142	113.3
SPE 17-41[2)]	26	3133	817	3950	139.5	175	152.5
SPE 17-48[2)]	30	3556	817	4373	139.5	175	164.2
SPE 17-58[2)]	37	4161	947	5108	139.5	181[1)]	195.9

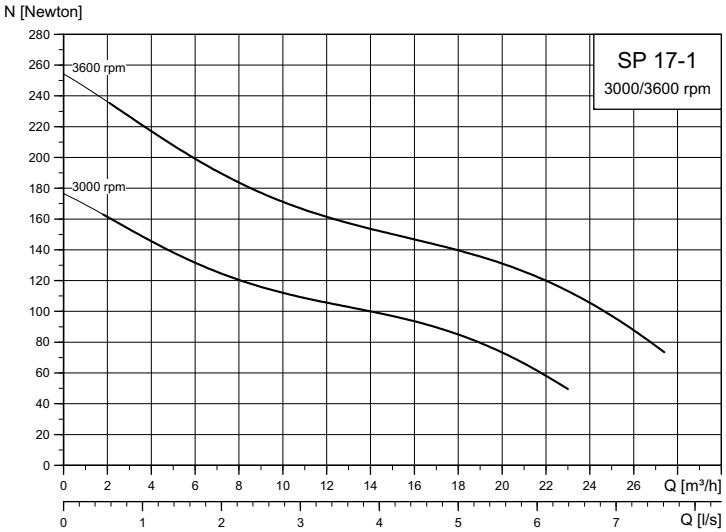
[1)] Maximum diameter of pump with two motor cables.

[2)] SPE 17-41, SPE 17-48 and SPE 17-58 are mounted in sleeve for R 3 connection. Pumps mounted in sleeve are only available in standard and N-versions.

The pump types listed are also available in N- and R-versions. See page 10.

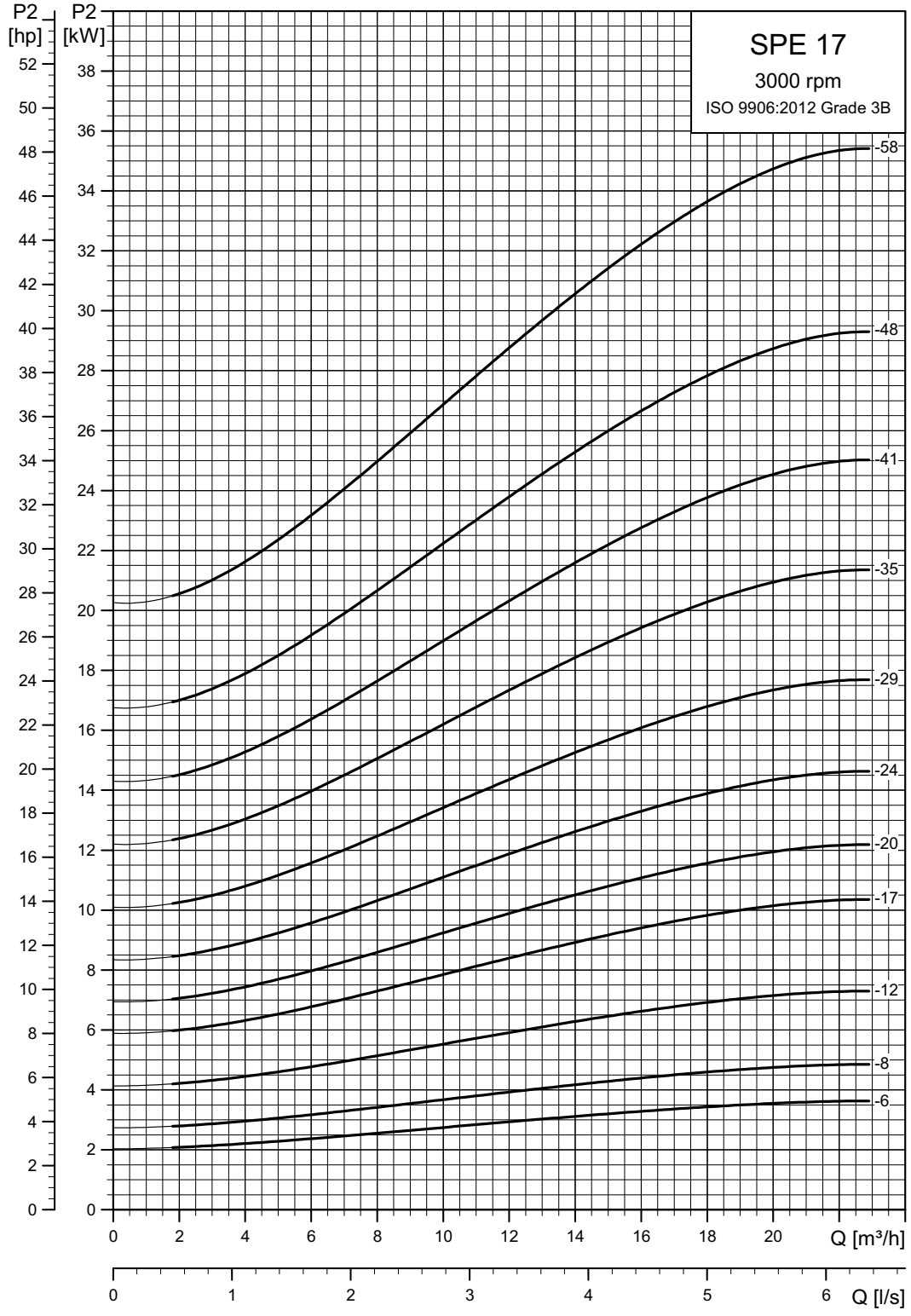
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6260 1220

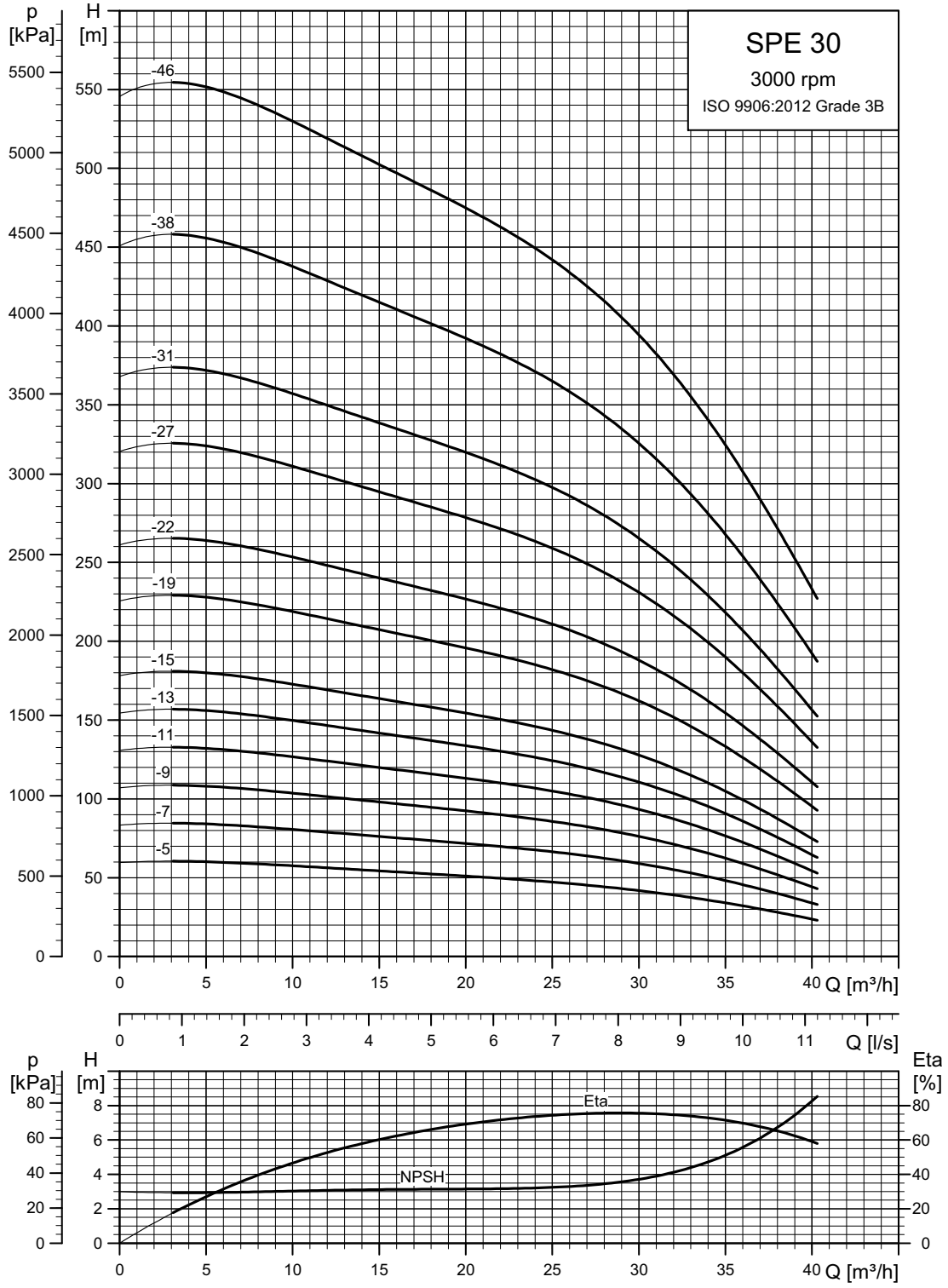
Power curves



TM07 6150 1220

SPE 30

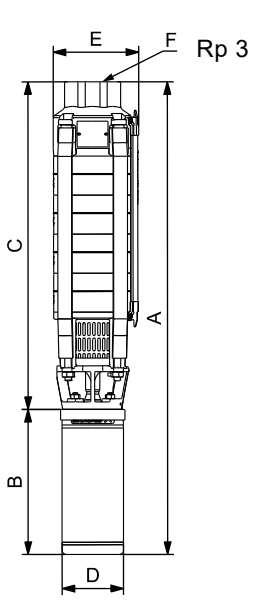
Performance curves

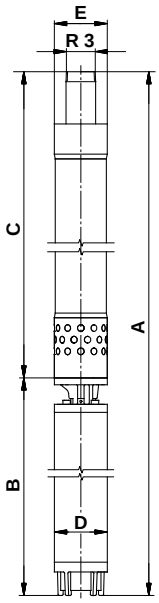


TM07 6151 1220

See also section *How to read the curve charts* on page 24.

Dimensions and weights





TM01 4197 4118 - TM06 5398 0818

Pump type	Motor	Dimensions [mm]					Net weight[kg]
	Power[kW]	C	B	A	D	E	
SPE 30-5	5.5	761	547	1308	139.5	142	46.8
SPE 30-7	7.5	953	547	1500	139.5	142	50.7
SPE 30-9	9.2	1145	667	1812	139.5	142	67.6
SPE 30-11	11	1337	667	2004	139.5	142	71.4
SPE 30-13	13	1529	667	2196	139.5	142	75.3
SPE 30-15	15	1721	667	2388	139.5	142	79.2
SPE 30-19	18.5	2121	667	2788	139.5	142	87.0
SPE 30-22	22	2409	817	3226	139.5	142	107.8
SPE 30-27	26	2889	817	3706	139.5	142	117.5
SPE 30-31	30	3273	817	4090	139.5	142	125.2
SPE 30-38[2)]	37	4300	947	5247	139.5	181[1)]	201.5
SPE 30-46[2)]	45	5068	947	6015	139.5	181[1)]	222.8

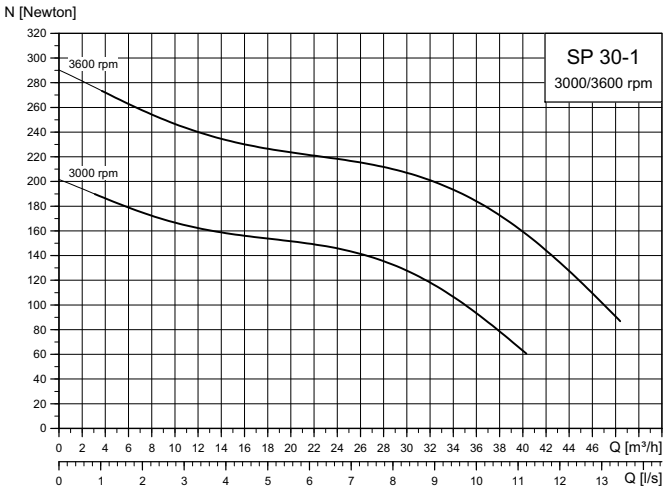
1) Maximum diameter of pump with two motor cables.

2) SPE 30-38 and 30-46 are mounted in sleeve for R 3 connection. Pumps mounted in sleeve are only available in standard and N-versions.

The pump types listed are also available in N- and R-versions. See page 10.

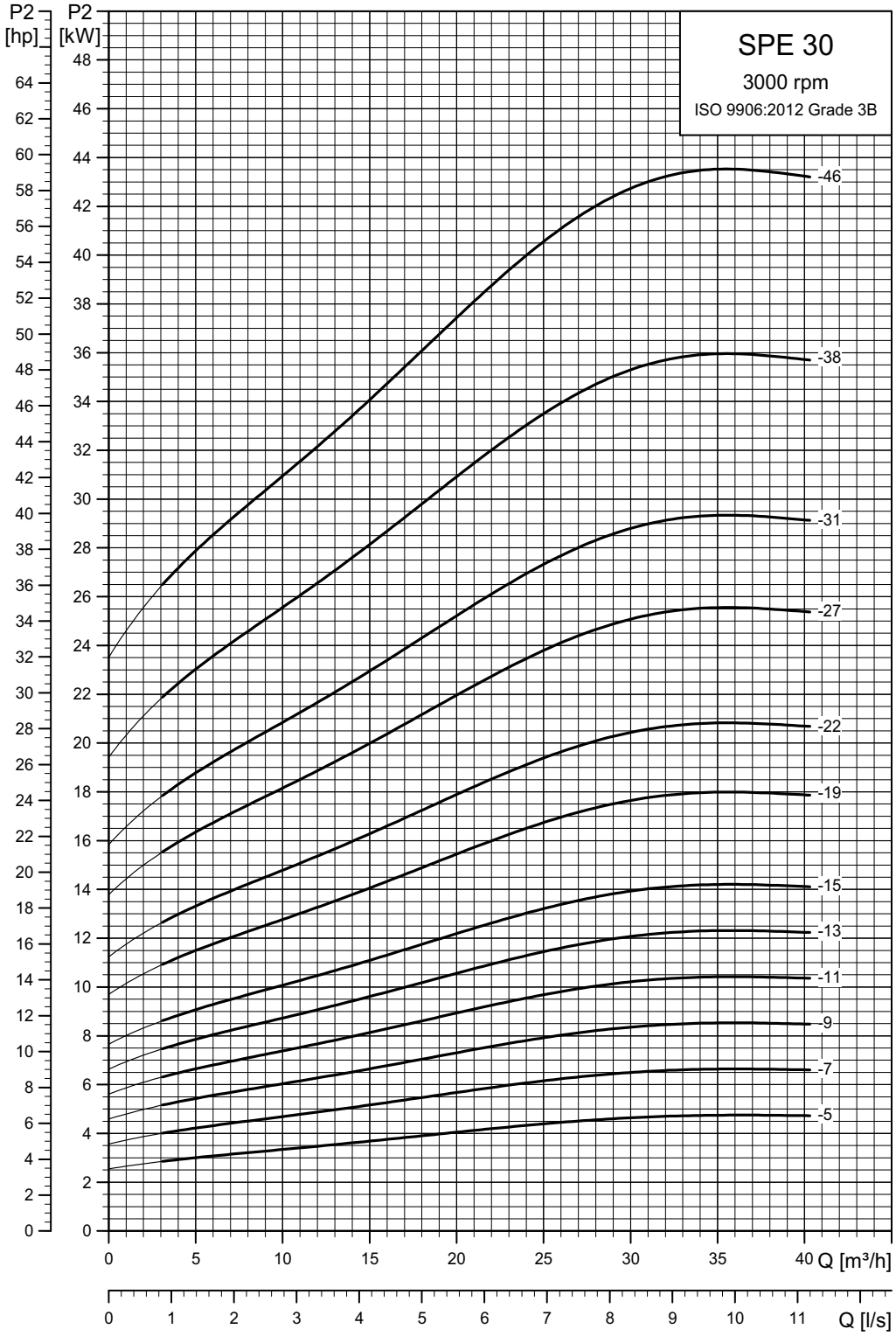
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6261 1220

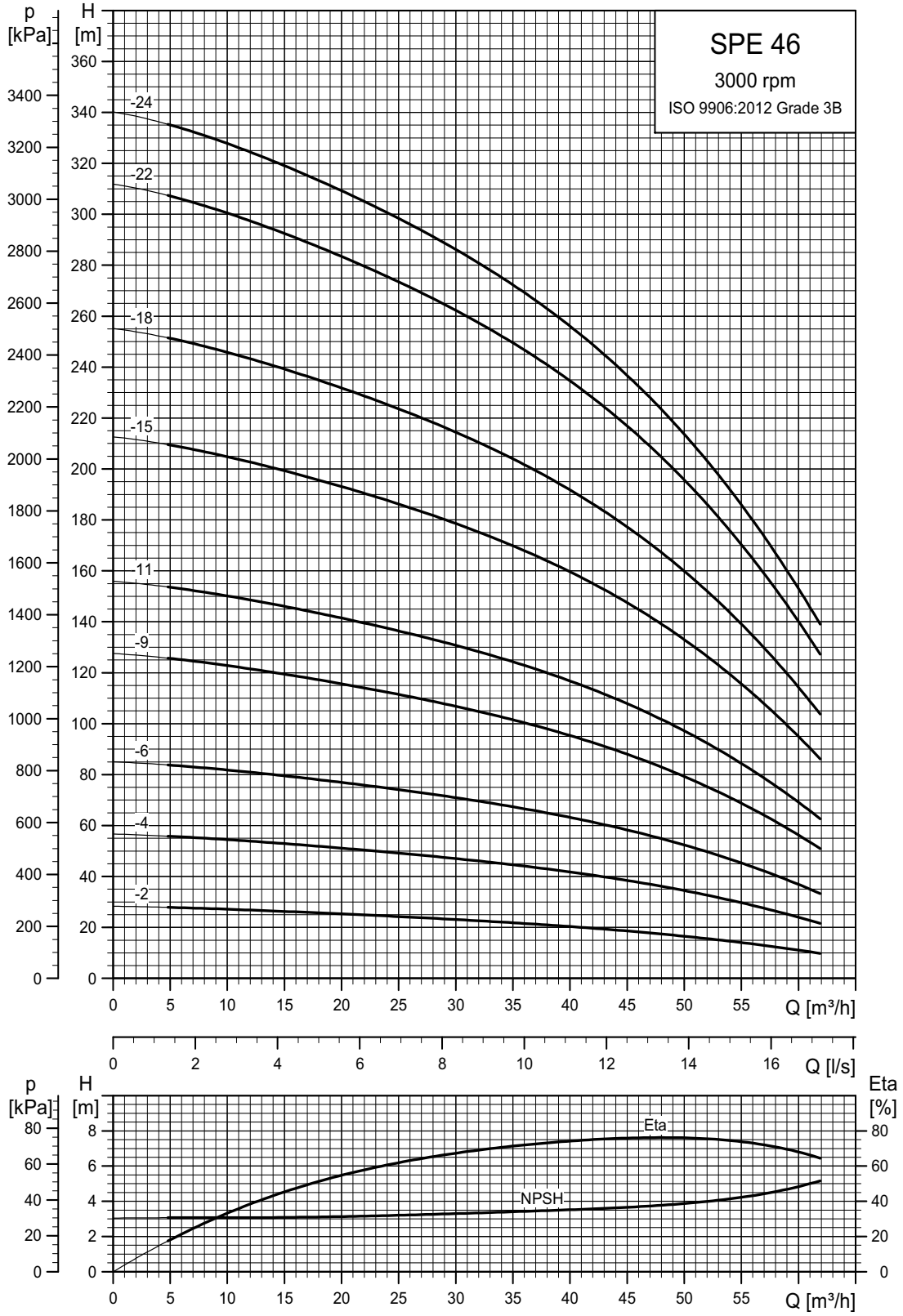
Power curves



TM07 6152 1220

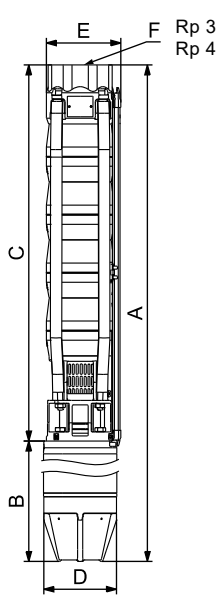
SPE 46

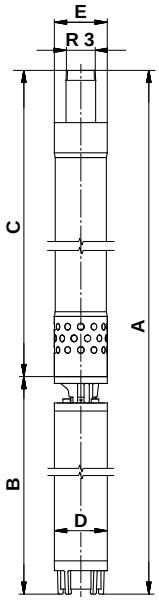
Performance curves



See also section *How to read the curve charts* on page 24.

Dimensions and weights





TM01 4197 4118 - TM06 5399 0818

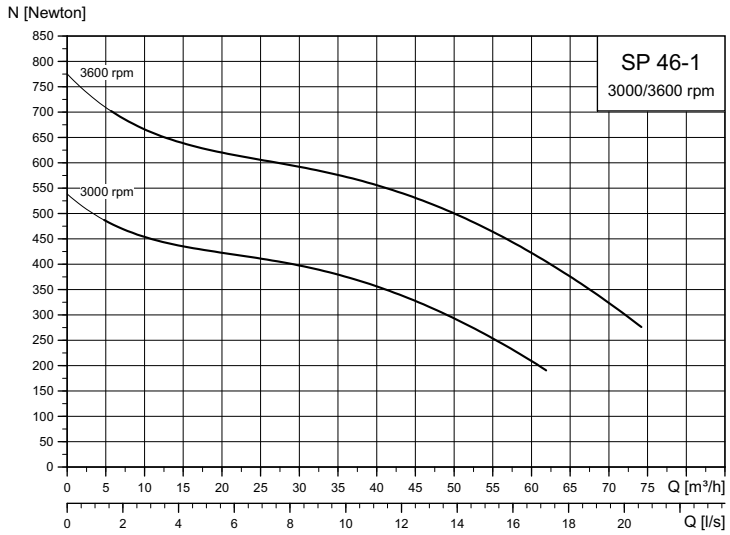
Pump type	Motor Power[kW]	Dimensions [mm]					Net weight[kg]
		C	B	A	D	E	
SPE 46-2	4.0	507	547	1054	139.5	148	43.0
SPE 46-4	7.5	733	547	1280	139.5	148	47.8
SPE 46-6	11	959	667	1626	139.5	148	65.6
SPE 46-9	15	1298	667	1965	139.5	148	72.8
SPE 46-11	18.5	1524	667	2191	139.5	148	77.6
SPE 46-15	22	1992	817	2809	139.5	148	102.2
SPE 46-18	30	2331	817	3148	139.5	148	109.4
SPE 46-22	37	2783	947	3730	139.5	151[1)]	134.0
SPE 46-24	45	3009	947	3956	139.5	151[1)]	138.8

1) Maximum diameter of pump with two motor cables.

The pump types listed are also available in N- and R-versions. See page 10.

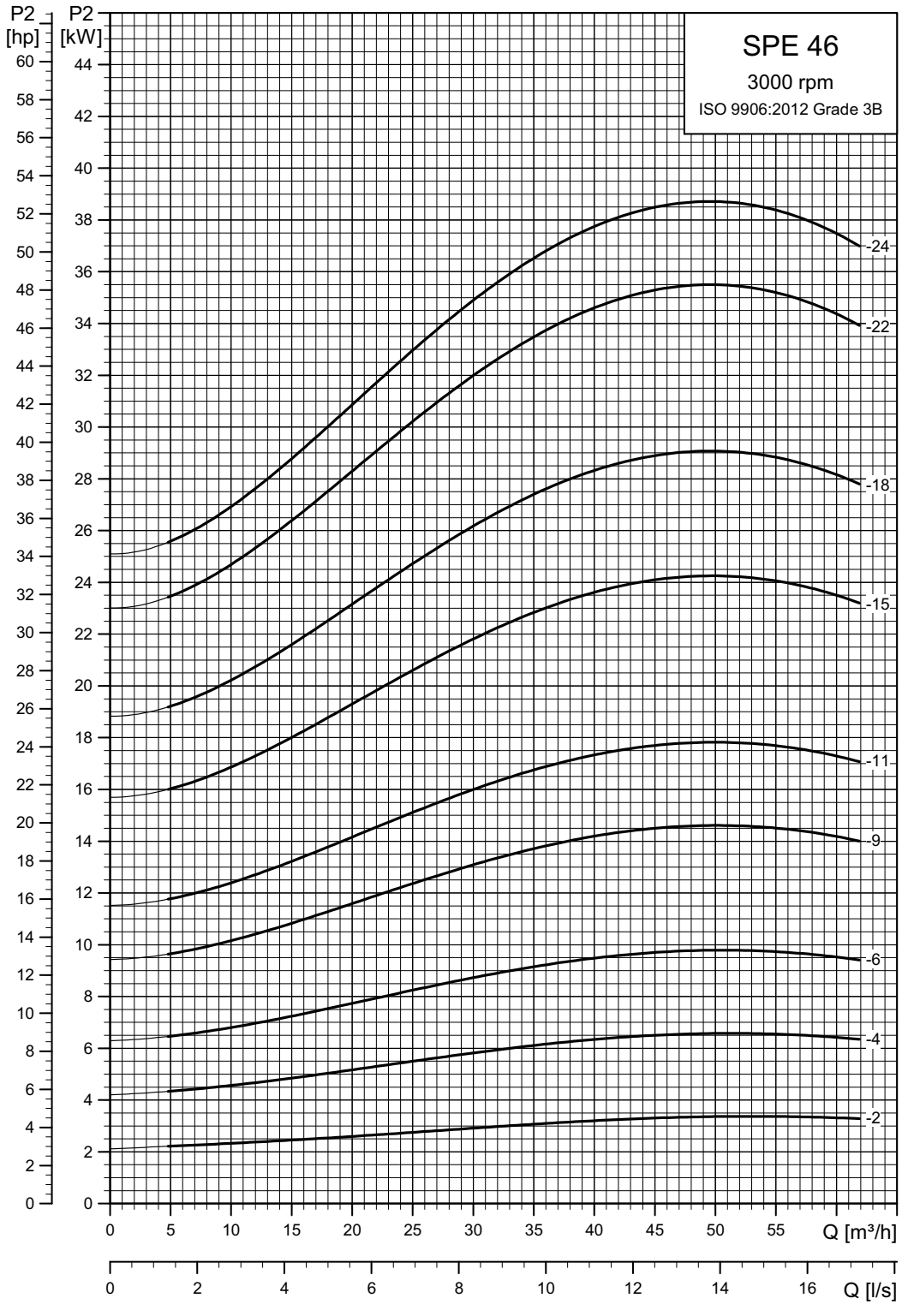
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6262 1220

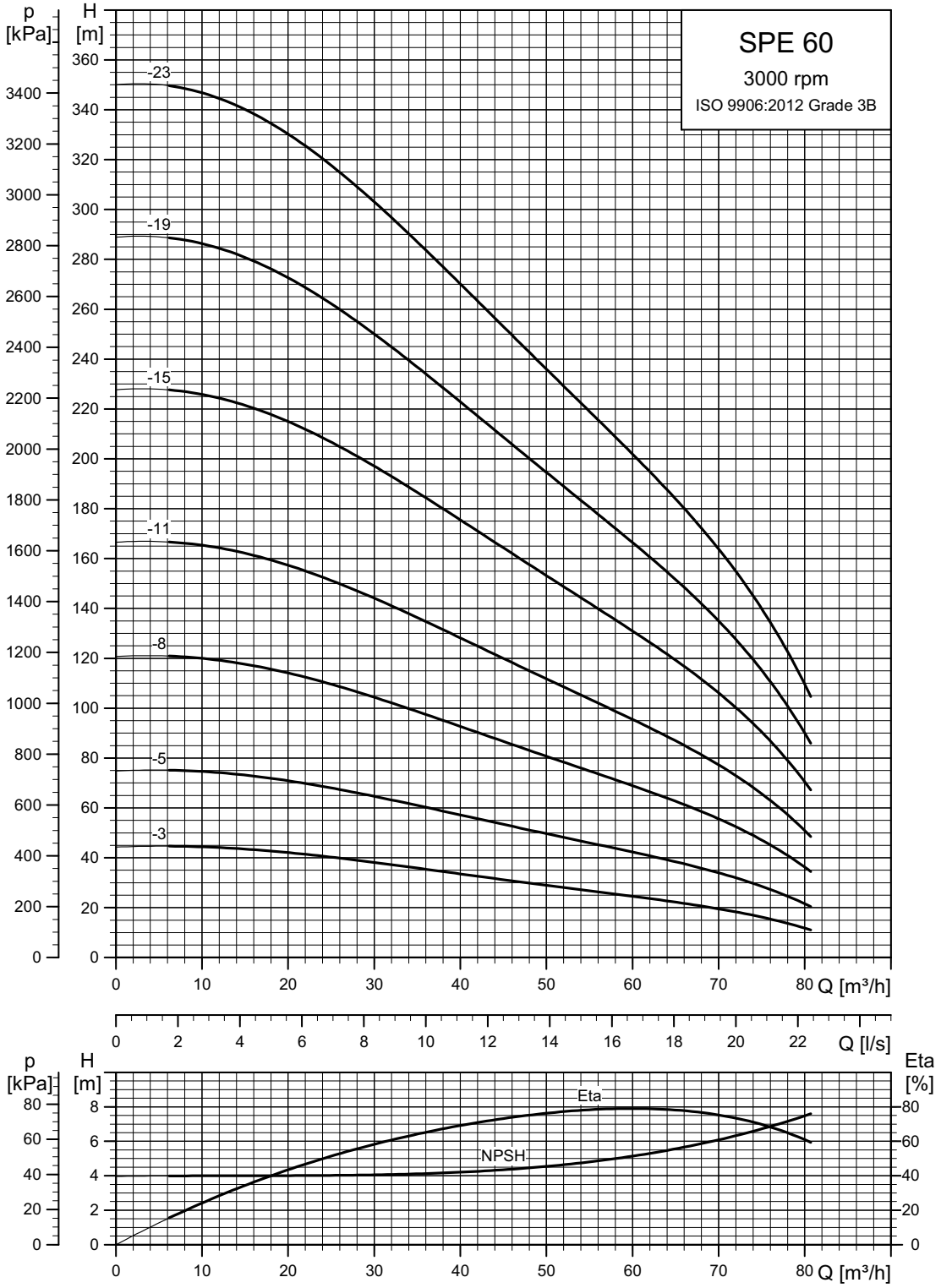
Power curves



TM07 6154 1220

SPE 60

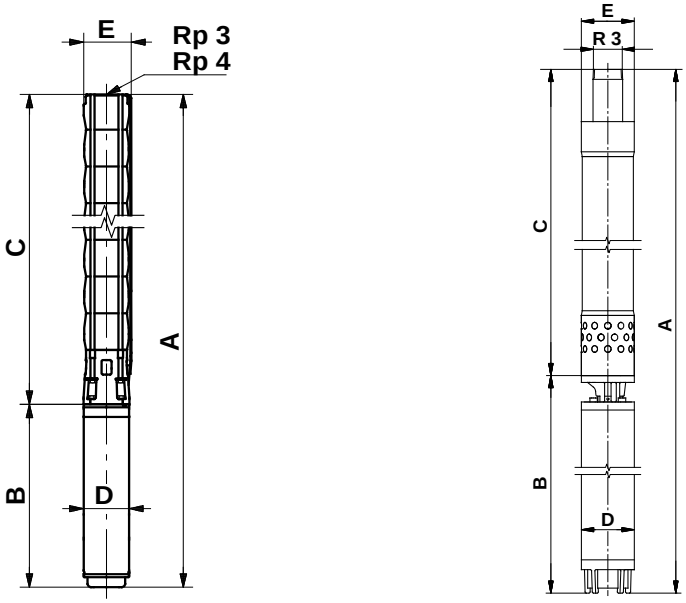
Performance curves



TM07 6155 1220

See also section *How to read the curve charts* on page 24.

Dimensions and weights



TM01 4197 4118 TM00 0961 1196

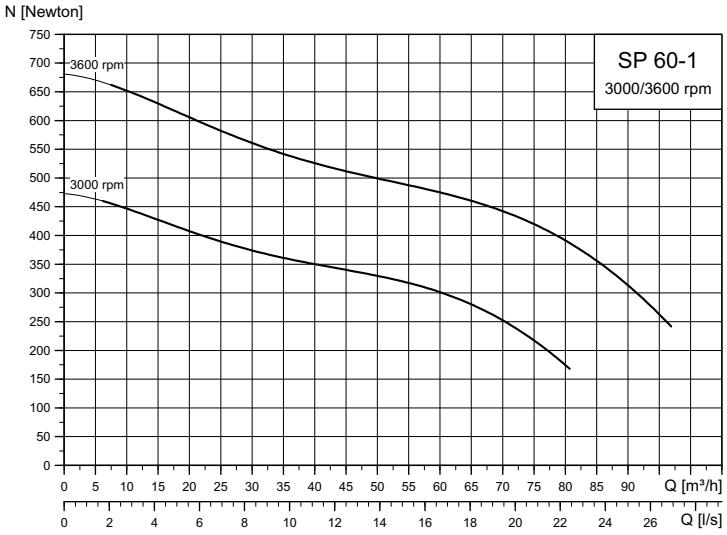
Pump type	Motor Power [kW]	Dimensions [mm]					Net weight [kg]
		C	B	A	D	E	
SPE 60-3	7.5	620	547	1167	139.5	148	45.4
SPE 60-5	11	846	667	1513	139.5	148	63.2
SPE 60-8	18.5	1185	667	1852	139.5	148	70.4
SPE 60-11	22	1524	817	2341	139.5	148	92.6
SPE 60-15	26	1992	817	2809	139.5	148	102.2
SPE 60-19	37	2444	947	3391	139.5	151[1)]	126.8
SPE 60-23	45	2896	947	3843	139.5	151[1)]	136.4

[1)] Maximum diameter of pump with two motor cables.

The pump types listed are also available in N- and R-versions. See page 10.

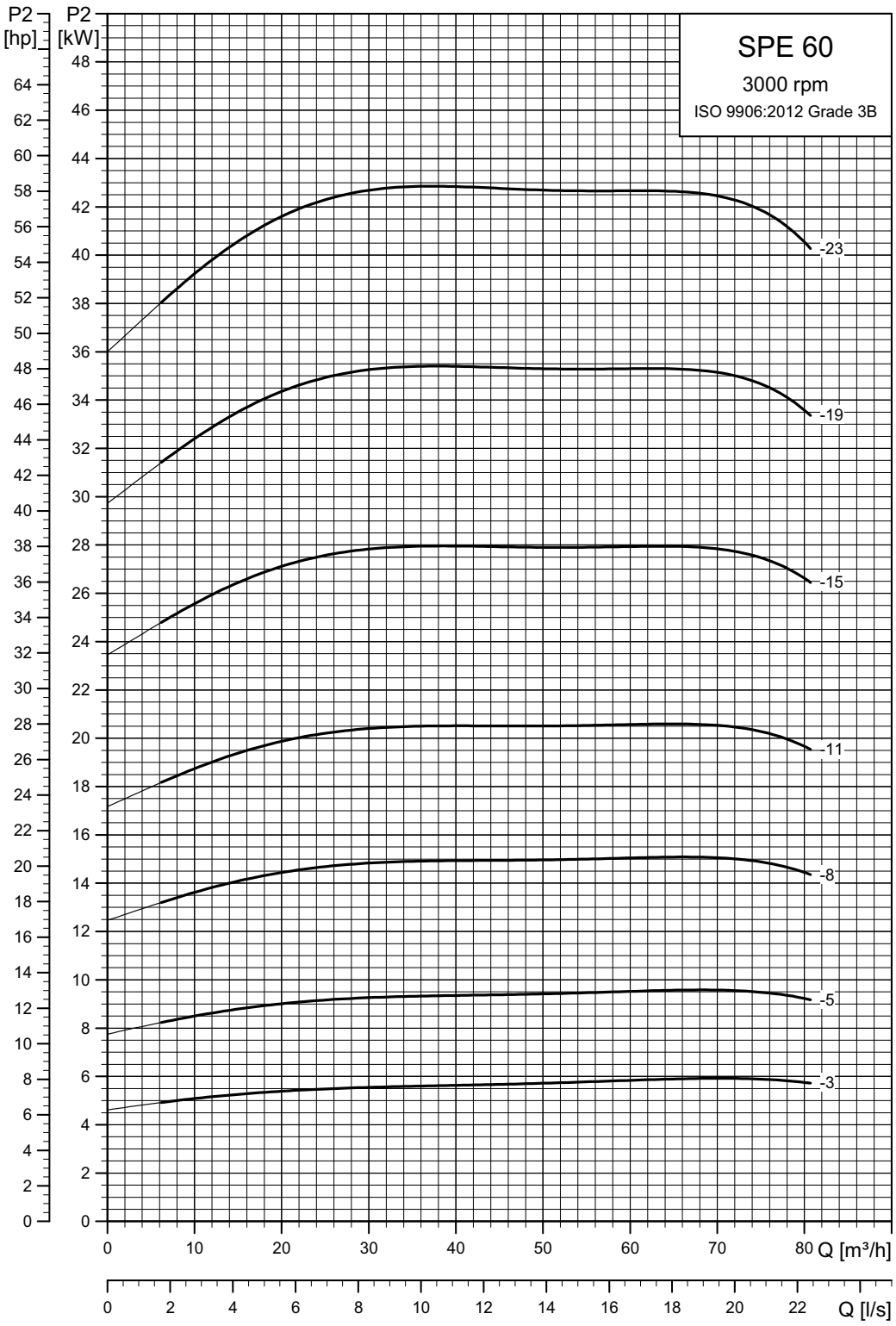
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6263 1220

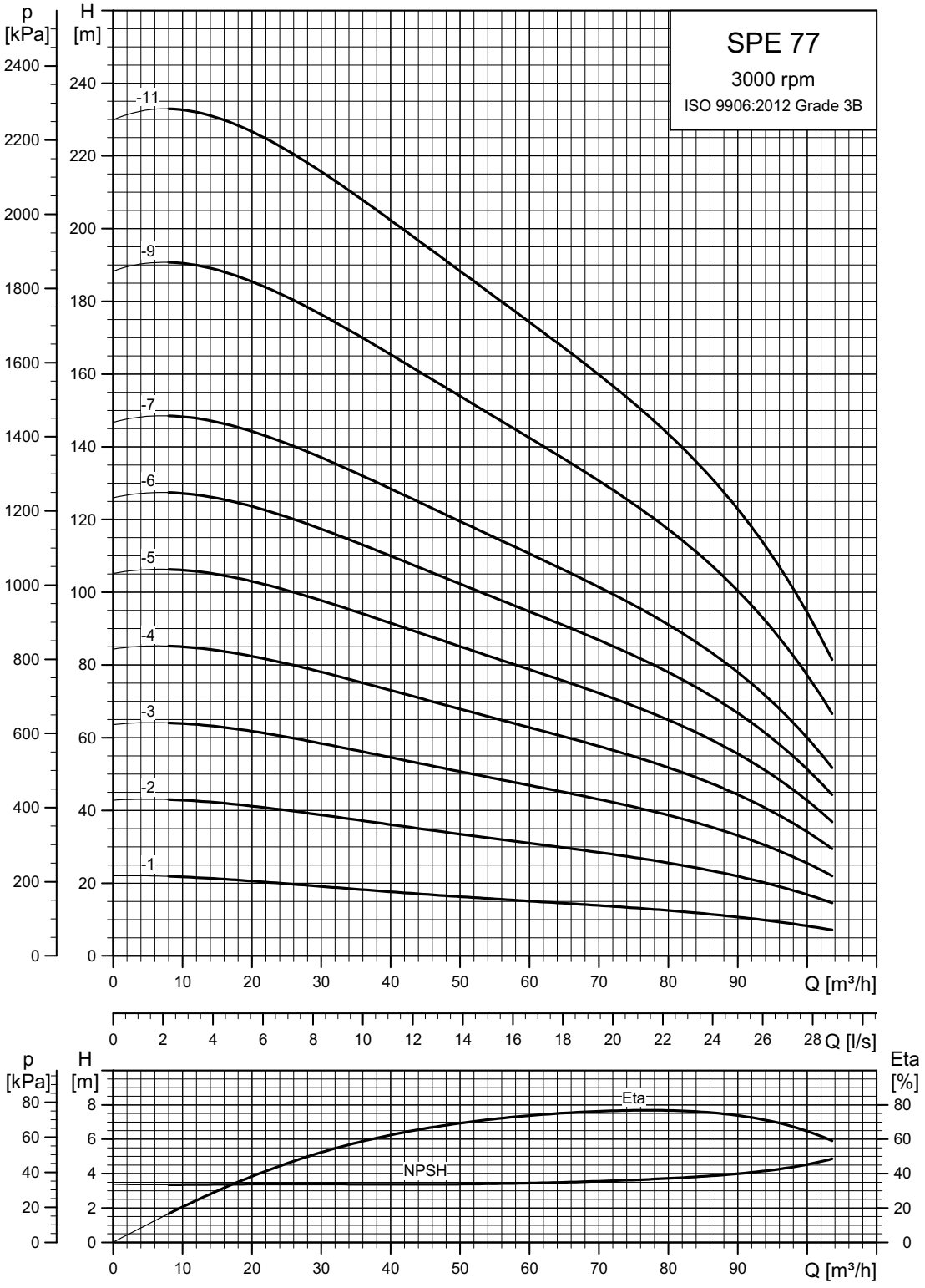
Power curves



TM07 6156 1220

SPE 77

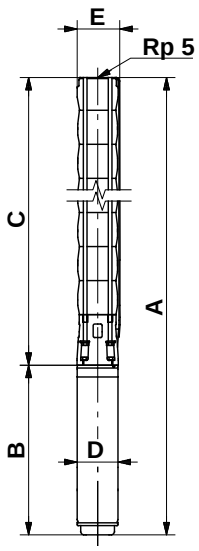
Performance curves



TM07 6157 1220

See also section *How to read the curve charts* on page 24.

Dimensions and weights



TM00 7872 2196

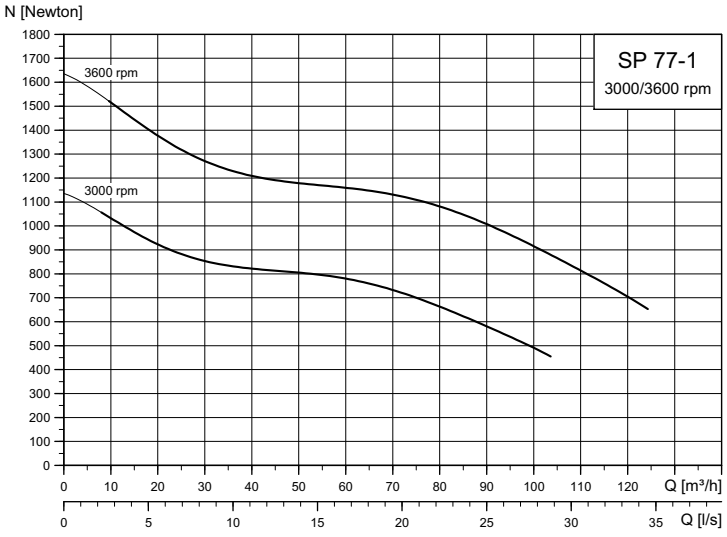
Pump type	Motor Power[kW]	Dimensions					Net weight[kg]
		C	B	A	D	E	
SPE 77-1	4.0	619	547	1166	139.5	178	56.2
SPE 77-2	9.2	747	667	1414	139.5	178	73.4
SPE 77-3	13	875	667	1542	139.5	178	77.6
SPE 77-4	18.5	1003	667	1670	139.5	178	81.8
SPE 77-5	22	1131	817	1948	139.5	178	101.0
SPE 77-6	26	1259	817	2076	139.5	178	105.2
SPE 77-7	30	1387	817	2204	139.5	178	109.4
SPE 77-9	37	1643	947	2590	139.5	186[1)]	132.8
SPE 77-11	45	1899	947	2846	139.5	186[1)]	141.2

[1)] Maximum diameter of pump with two motor cables.

The pump types above are also available in N- and R-versions. See page 10.

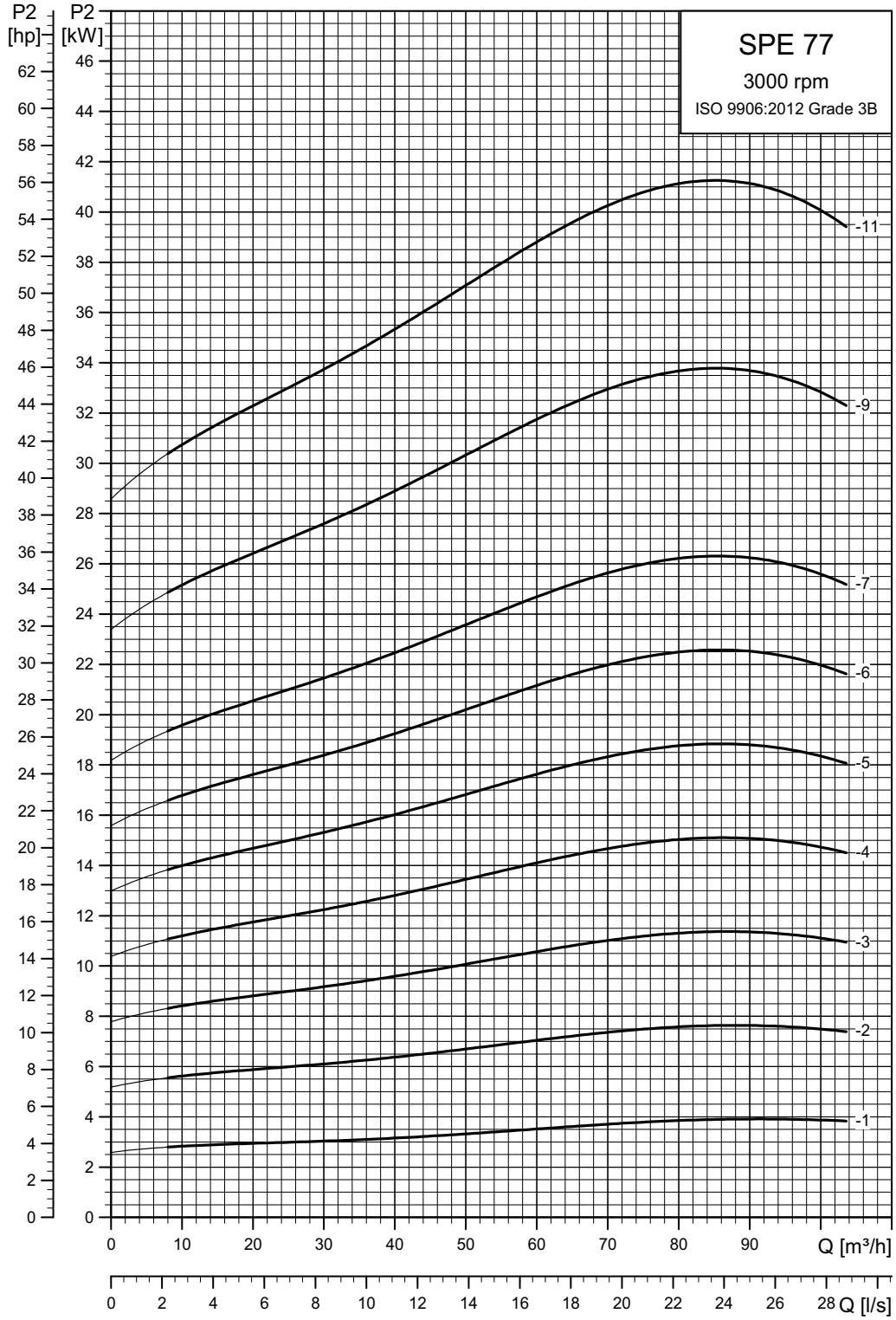
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6264 1220

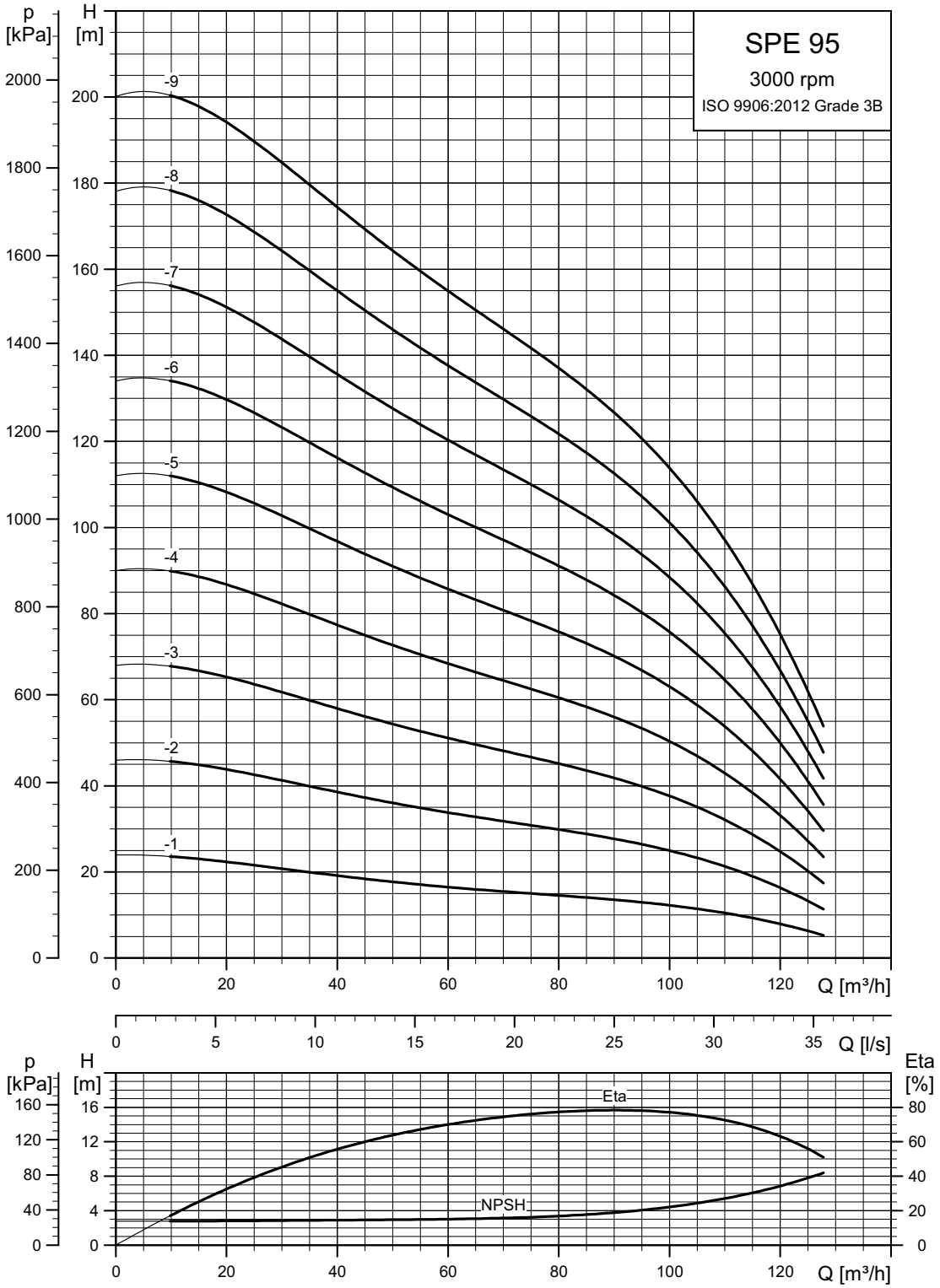
Power curves



TM07 6158 1220

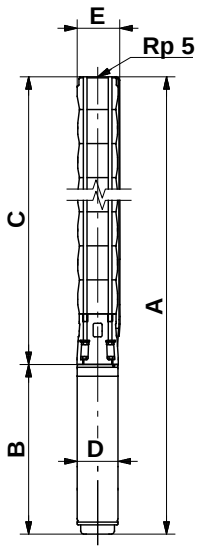
SPE 95

Performance curves



See also section *How to read the curve charts* on page 24.

Dimensions and weights



TM00 7872 2196

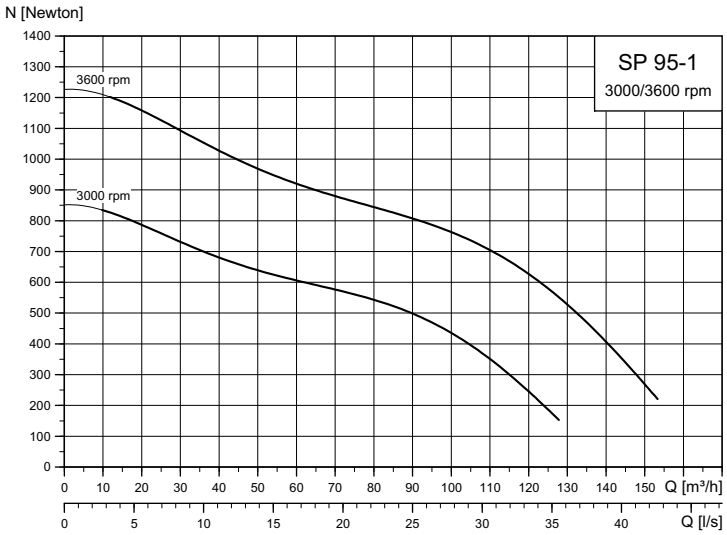
Pump type	Motor Power[kW]	Dimensions					Net weight[kg]
		C	B	A	D	E	
SPE 95-1	5.5	619	547	1166	139.5	178	56.2
SPE 95-2	11	747	667	1414	139.5	178	73.4
SPE 95-3	15	875	667	1542	139.5	178	77.6
SPE 95-4	22	1003	817	1820	139.5	178	96.8
SPE 95-5	26	1131	817	1948	139.5	178	101.0
SPE 95-6	30	1259	817	2076	139.5	178	105.2
SPE 95-7	37	1387	947	2334	139.5	186 [1)]	124.4
SPE 95-8	37	1515	947	2462	139.5	186 [1)]	128.6
SPE 95-9	45	1643	947	2590	139.5	186 [1)]	132.8

[1)] Maximum diameter of pump with two motor cables.

The pump types above are also available in N- and R-versions. See page 10.

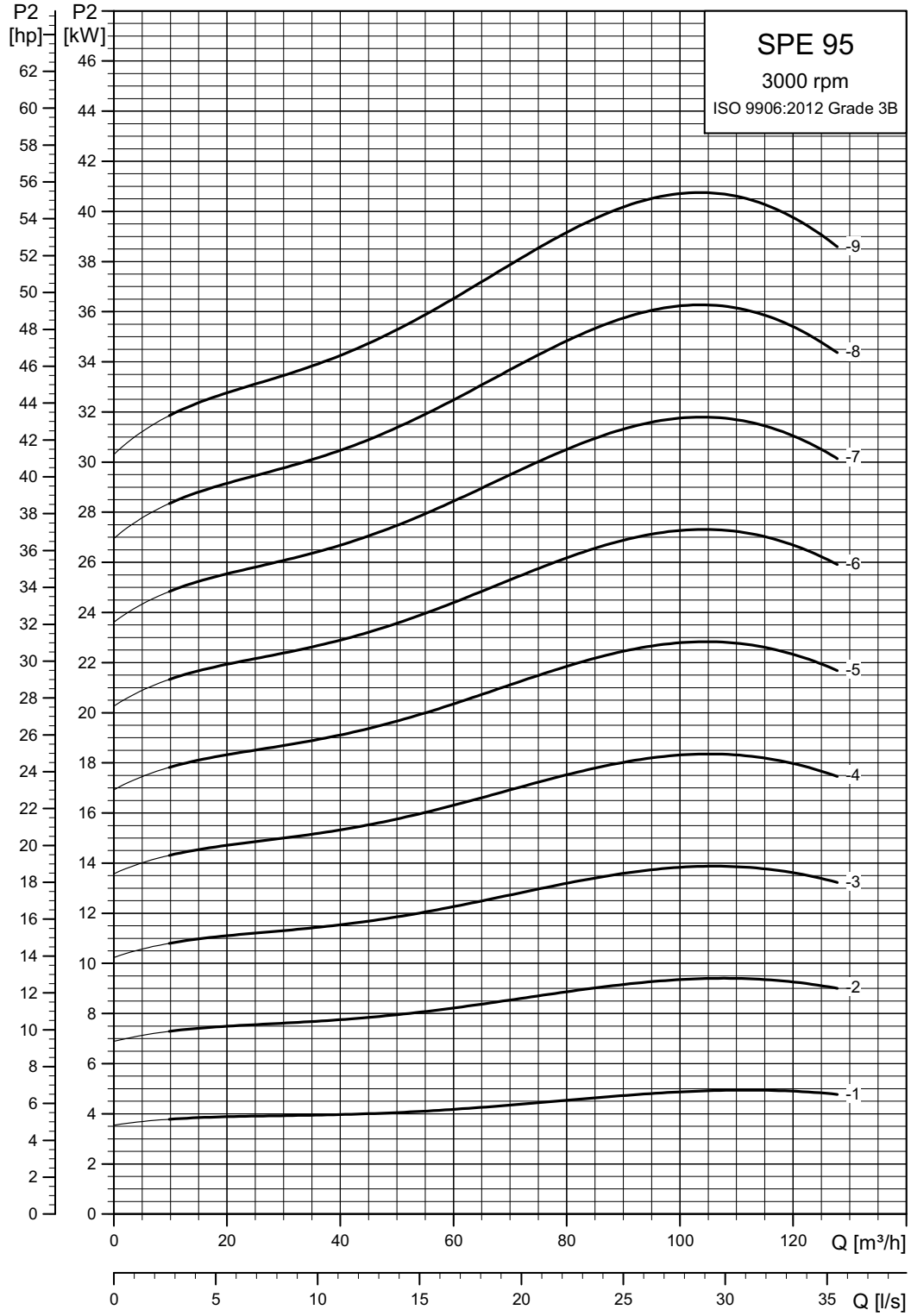
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6265 1220

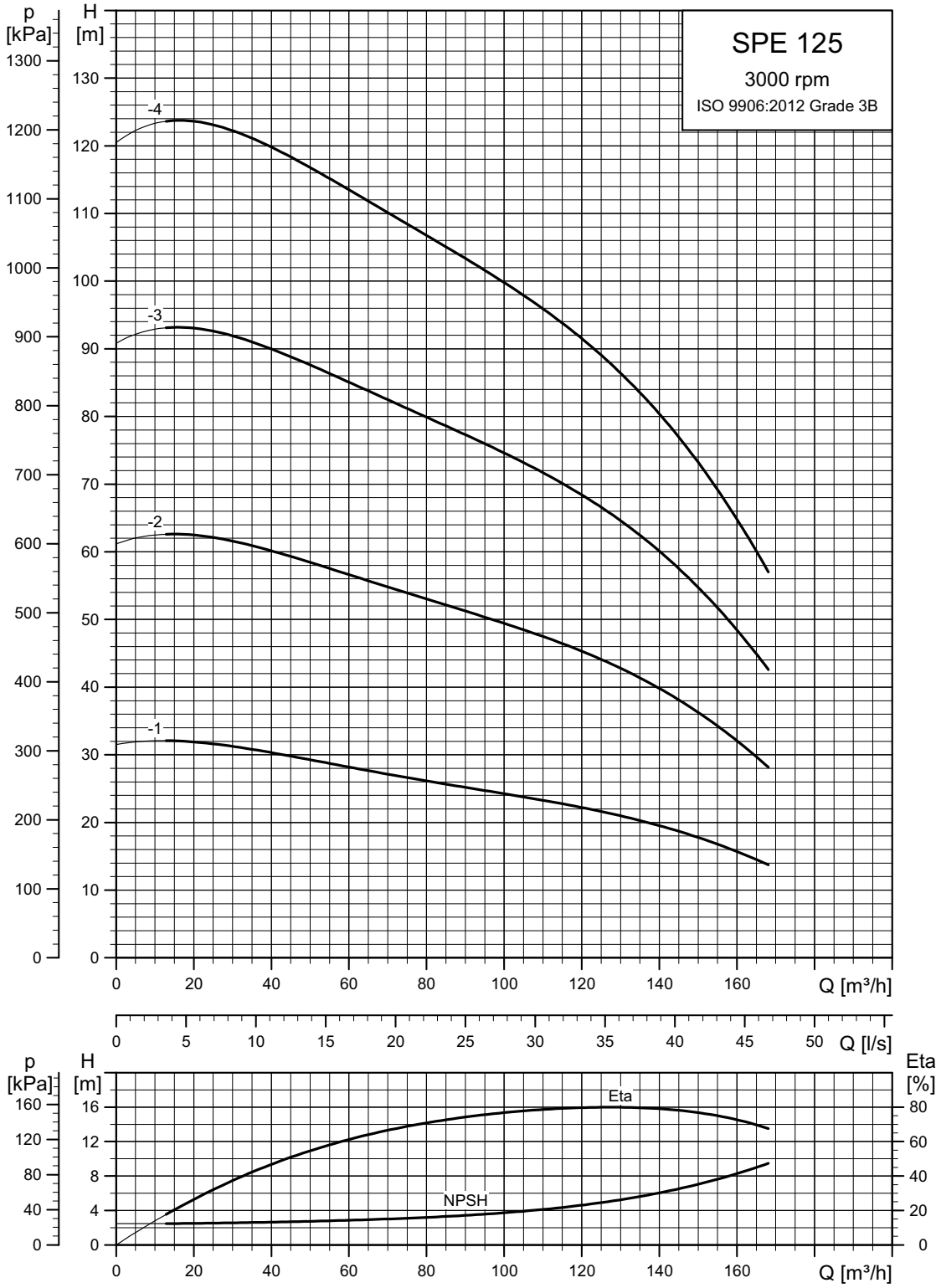
Power curves



TM07 6251 1220

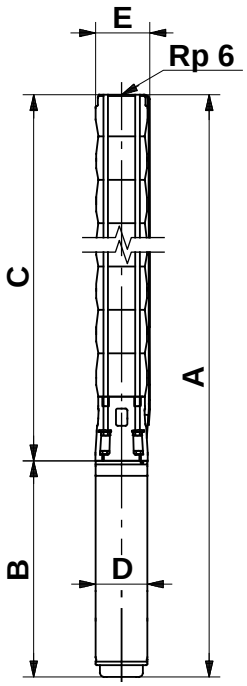
SPE 125

Performance curves



See also section *How to read the curve charts* on page 24.

Dimensions and weights



TM00 8760 3596

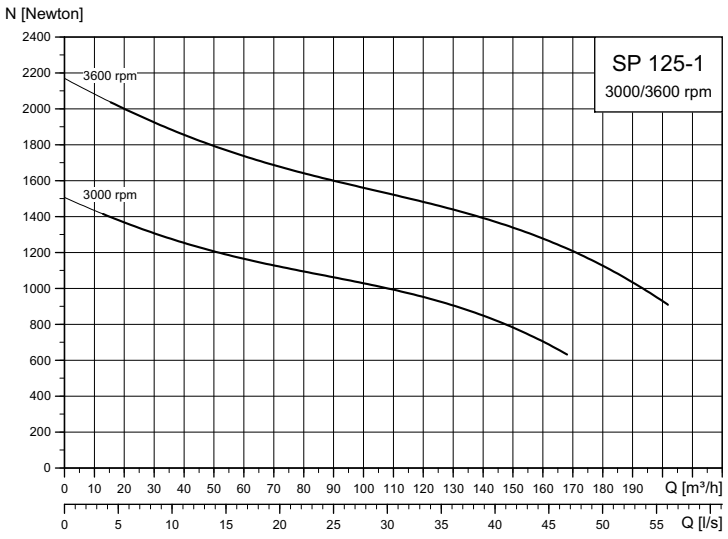
Pump type	Motor Power[kW]	Dimensions					Net weight[kg]
		C	B	A	D	E	
SPE 125-1	13	652	667	1319	139.5	211	79.2
SPE 125-2	22	807	817	1624	139.5	211	100.2
SPE 125-3	37	963	947	1910	139.5	215[1)]	121.2
SPE 125-4	45	1118	947	2065	139.5	215[1)]	127.2

[1)] Maximum diameter of pump with two motor cables.

The pump types above are also available in N- and R-versions. See page 10.

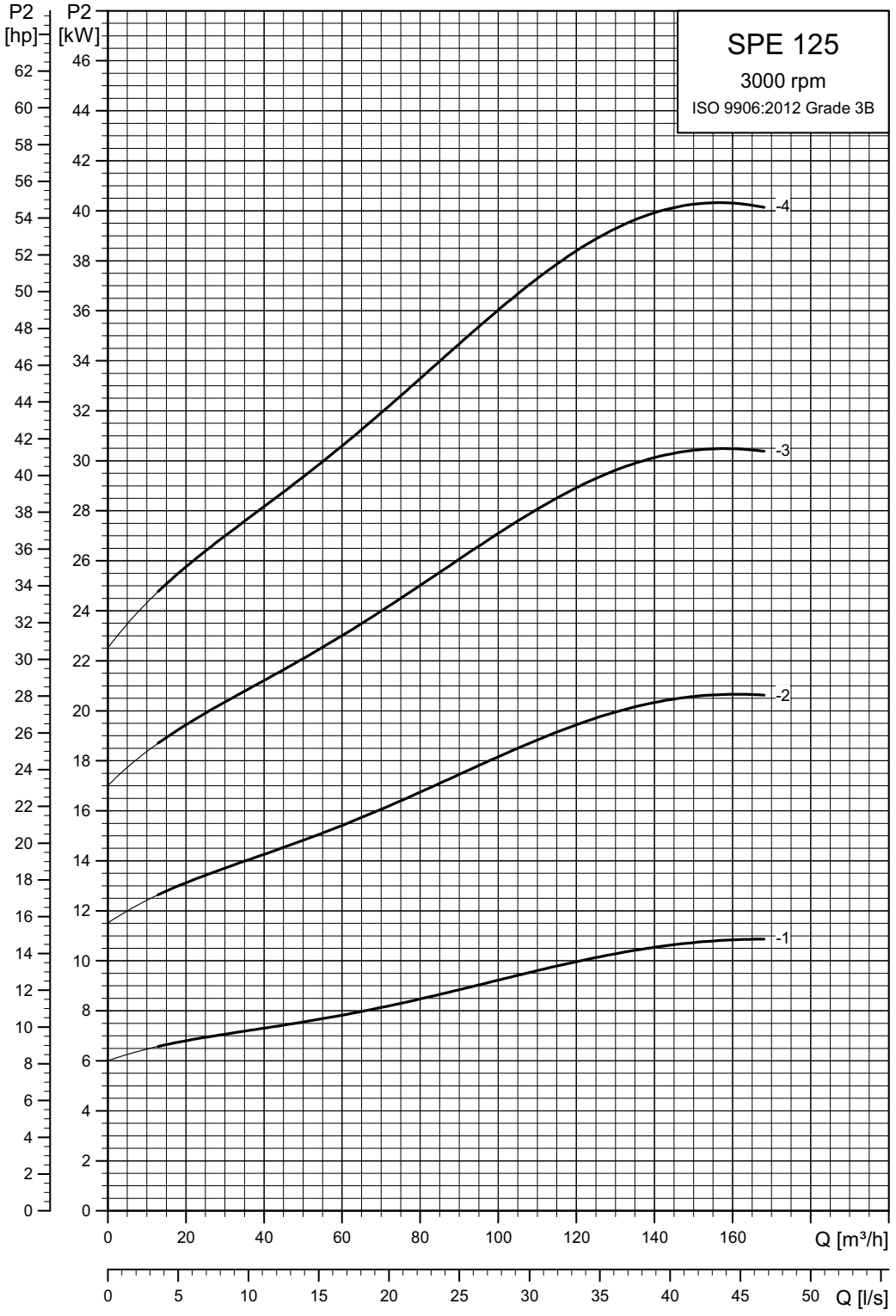
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6266 1220

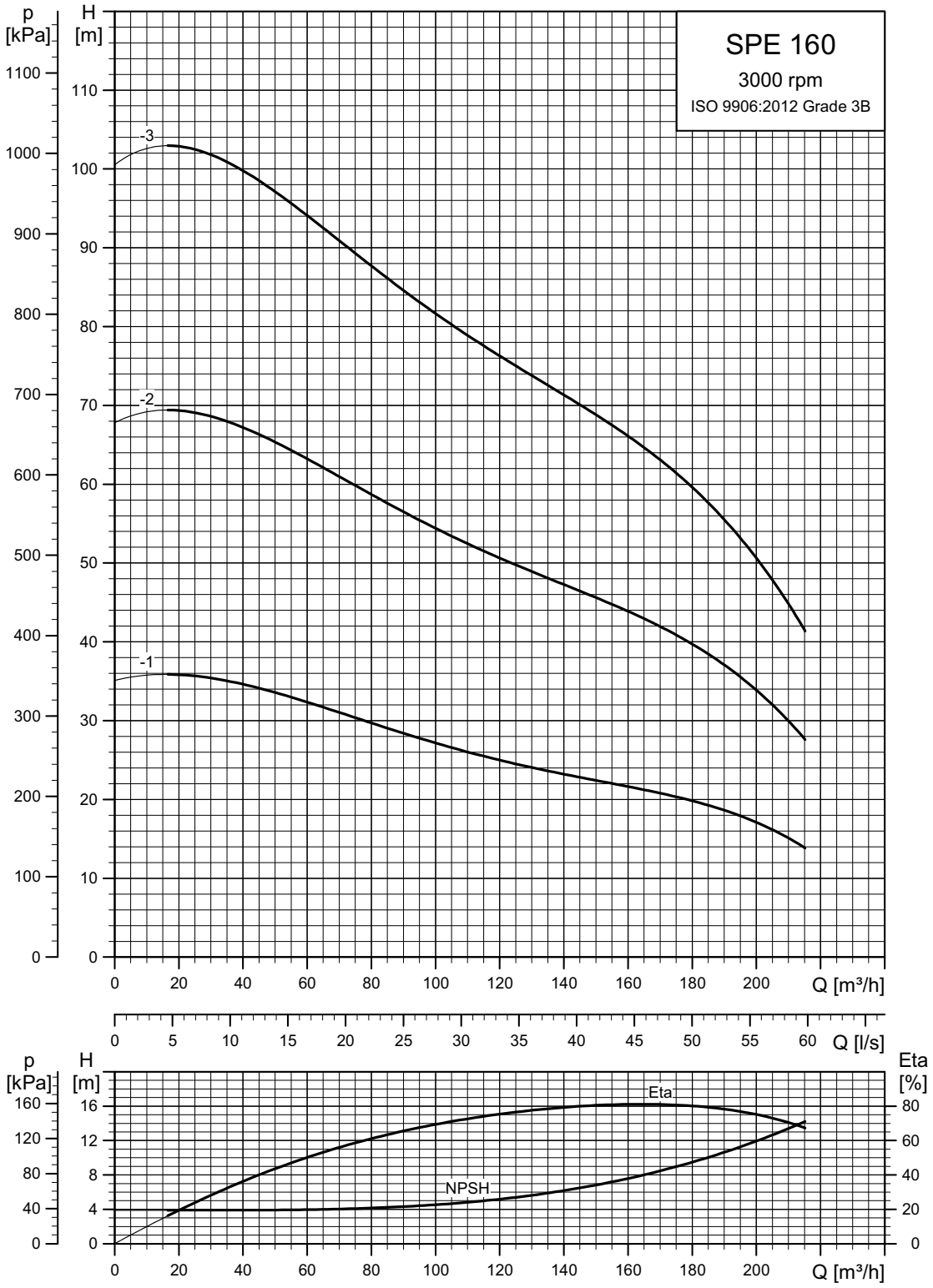
Power curves



TM07 6160 1220

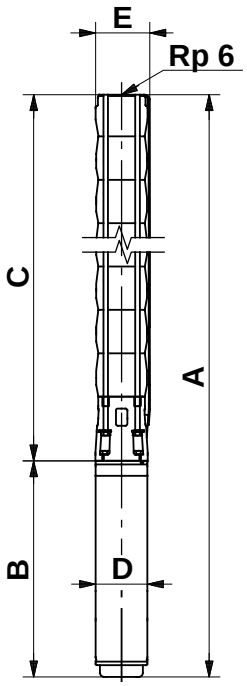
SPE 160

Performance curves



See also section *How to read the curve charts* on page 24.

Dimensions and weights



TM00 8760 3596

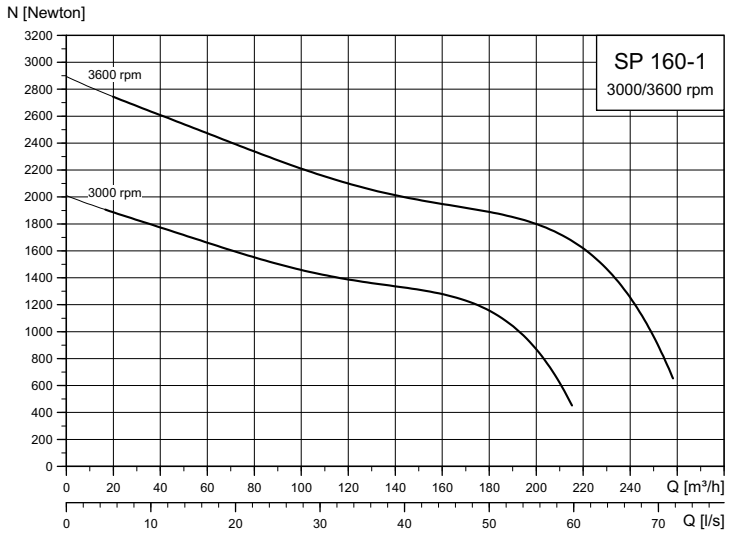
Pump type	Motor Power[kW]	Dimensions					Net weight[kg]
		C	B	A	D	E	
SPE 160-1	15	652	667	1319	139.5	211	79.2
SPE 160-2	30	807	817	1624	139.5	211	100.2
SPE 160-3	45	963	947	1910	139.5	215[1)]	121.2

1) Maximum diameter of pump with two motor cables.

The pump types above are also available in N- and R-versions. See page 10.

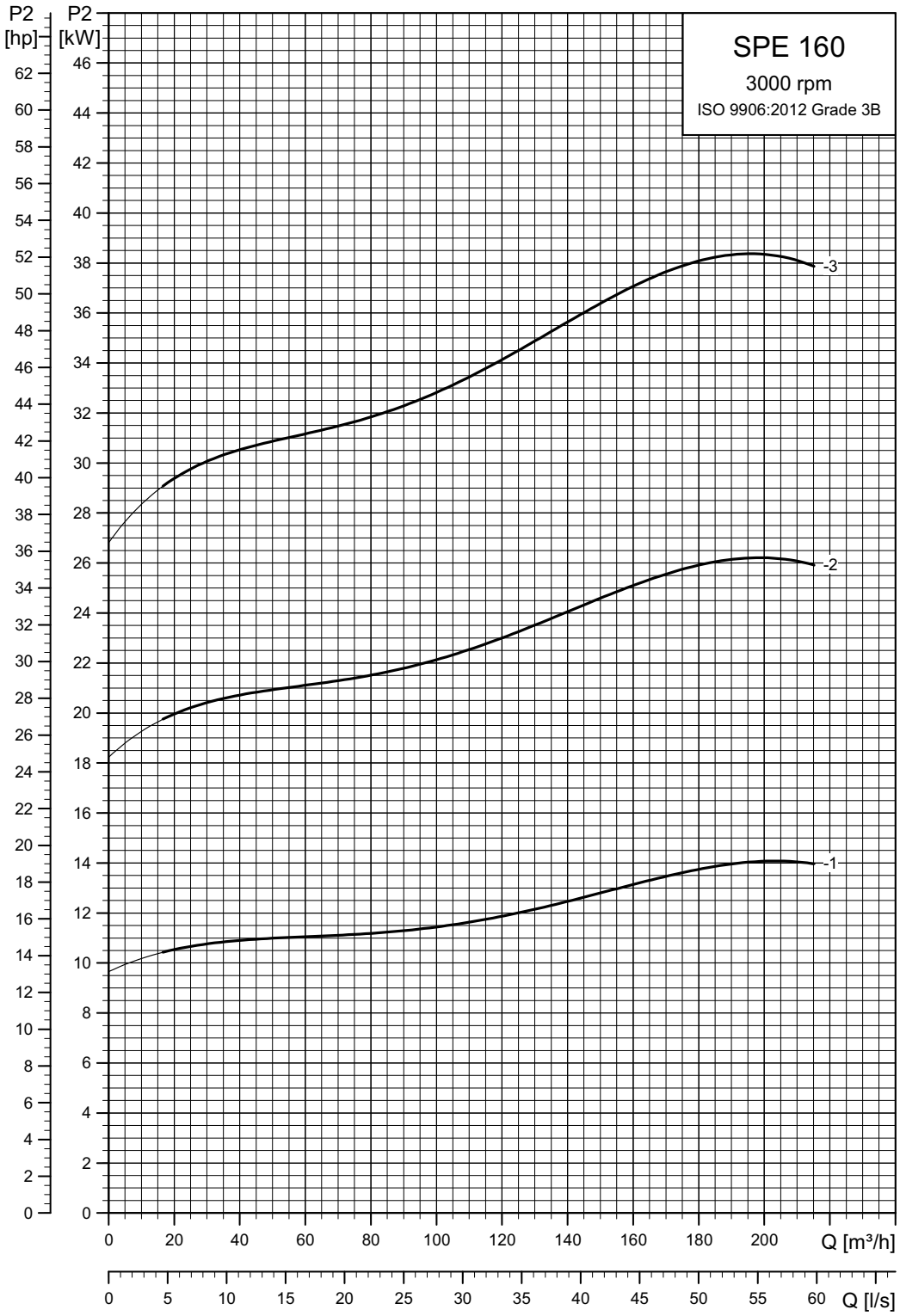
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6267 1220

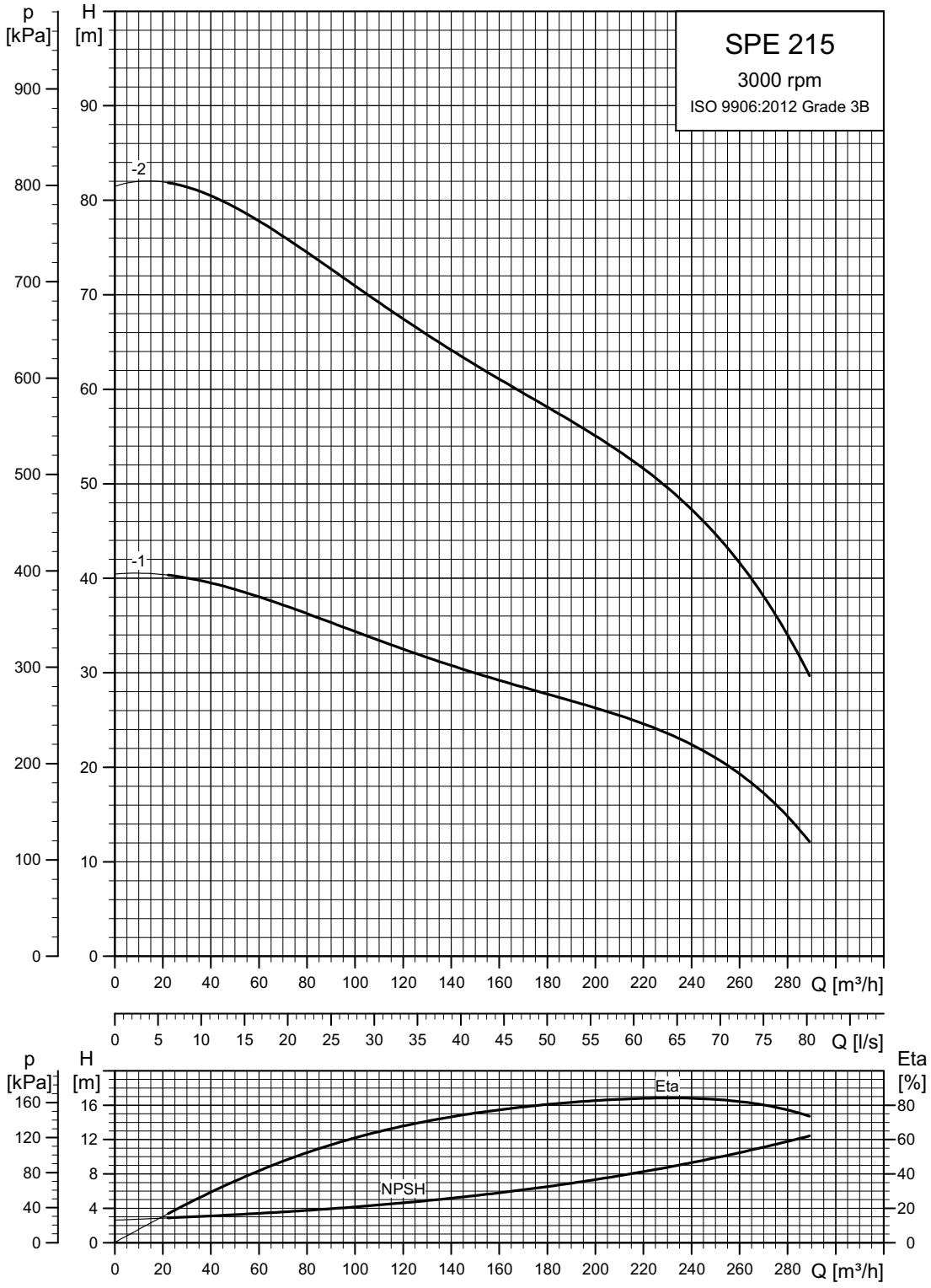
Power curves



TM07 6194 1220

SPE 215

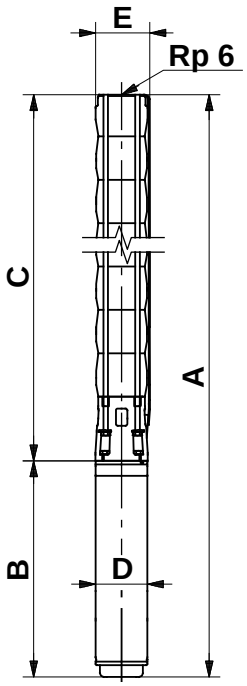
Performance curves



TM07 6195 1220

See also section *How to read the curve charts* on page 24.

Dimensions and weights



TM00 8760 3596

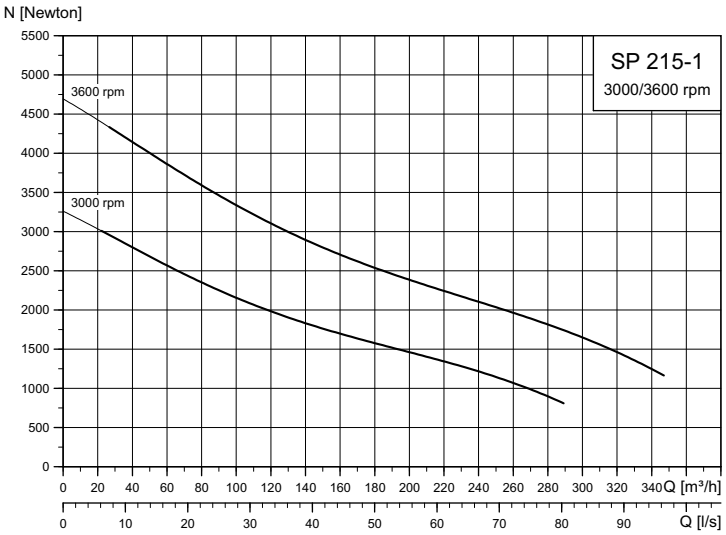
Pump type	Motor Power[kW]	Dimensions					Net weight[kg]
		C	B	A	D	E	
SPE 215-1	22	790	817	1607	139.5	236	100.0
SPE 215-2	45	966	947	1913	139.5	239	125.0

1) Maximum diameter of pump with two motor cables.

The pump types above are also available in N- and R-versions. See page 10.

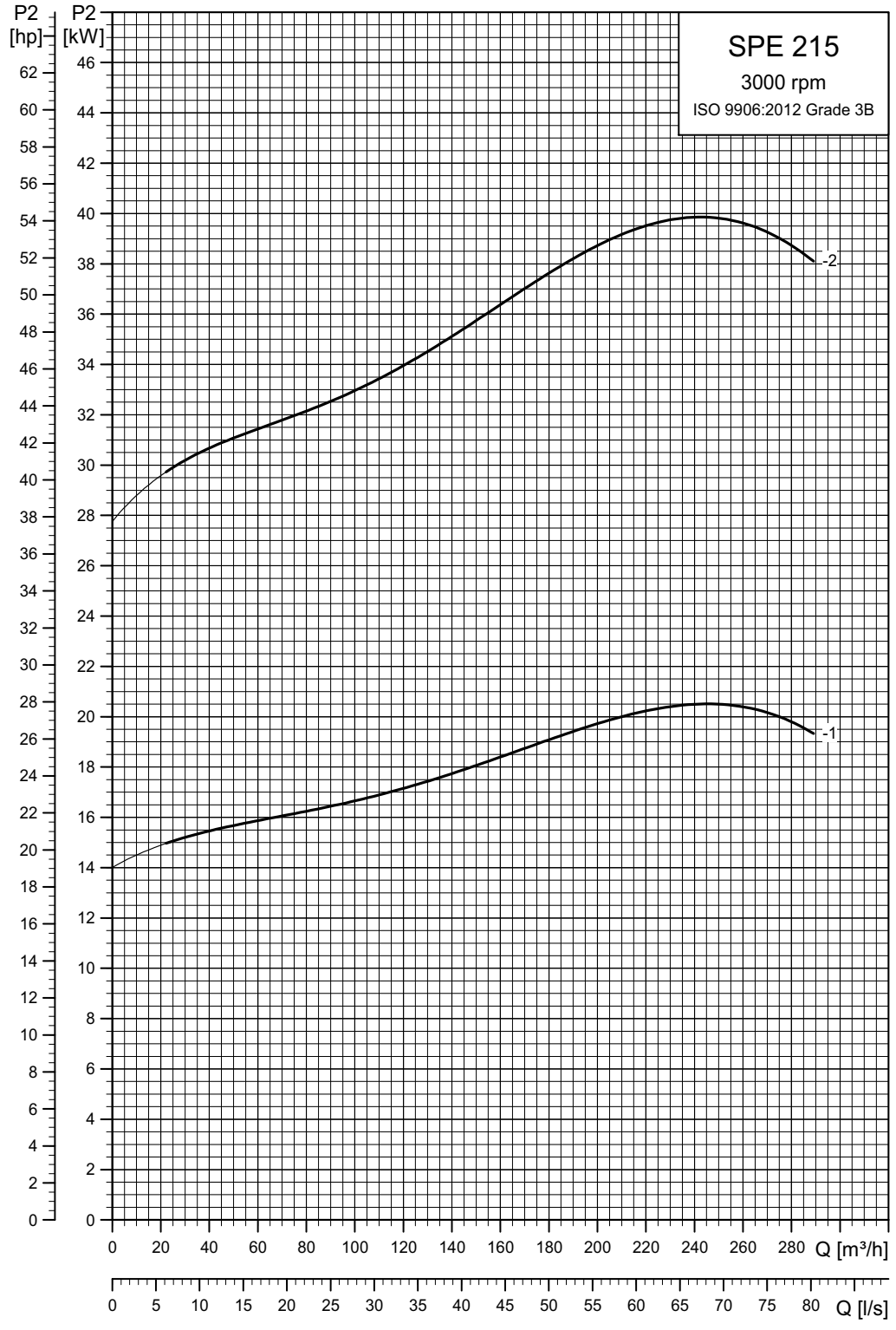
Other types of connection are possible by means of connecting pieces. See page 58.

Single-stage curves, axial thrust



TM07 6268 1220

Power curves



TM07 6196 1220

8. Electrical data

3 x 350 V 3000 rpm, MS6000P submersible motors T60

Electrical data									Dimensions	
Power [kW]	Full-load current I_n [A]	Motor efficiency [%]			Power factor			$\frac{I_{st}}{I_n}$ [%]	Build in length [mm]	Weight [kg]
		η50 %	η75 %	η100 %	Cos φ 50 %	Cos φ 75 %	Cos φ 100 %			
4.0	9.6	83.6	87.4	89.2	0.98	0.96	0.95			
5.5	12.6	86.8	89.3	90.3	0.97	0.94	0.92		547	32.9
7.5	16.6	88.9	90.3	90.5	0.95	0.92	0.88			
9.2	21.4	88.2	90.8	91.8	0.98	0.96	0.94			
11	25.0	89.6	91.6	92.2	0.97	0.95	0.93			
13	29.2	90.6	92.0	92.4	0.96	0.94	0.92		667	46.3
15	33.4	91.2	92.2	92.4	0.94	0.91	0.88	100		
18.5	40.6	91.8	92.4	92.0	0.94	0.91	0.88			
22	46.2	91.6	92.7	92.8	0.96	0.93	0.91			
26	54.0	92.2	92.8	92.6	0.95	0.92	0.90		817	61.3
30	61.8	92.5	92.8	92.4	0.94	0.91	0.90			
37	85.6	91.5	92.3	92.2	0.92	0.89	0.86		947	76.2
45	103.0	92.0	92.3	91.9	0.90	0.87	0.85			

9. Electrical accessories

Accessories for CUE

MCB 114 sensor input module

MCB 114 offers the following additional analog inputs for CUE:

- 1 analog input, 0/4-20 mA
- 2 inputs for Pt100 and Pt1000 temperature sensors.

Grundfos Communication Interface Units (CIU)

GrA6118 3908

Fig. 24 CIU

The CIU enables data communication through open and interoperable networks, such as the following:

- PROFIBUS DP
- PROFINET
- Modbus RTU
- Modbus TPC
- EtherNet/IP
- LON
- BACnet MS/TP
- BACnet IP
- Grundfos Remote Management (GRM) for complete control of pump systems.

Applications

The range of Grundfos CIU offers easy 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 units enable communication of operating data, such as measured values and setpoints, between pumps and the following:

- PLC
- SCADA system
- Building management system.

Benefits

The CIU offers the following benefits:

- open communication standards
- complete process control
- one concept for Grundfos products
- 24-240 VAC/DC power supply in CIU modules
- simple configuration and easy to install
- prepared for DIN rail or wall mounting.

For data communication between an SPE pump and a main network, a CIU unit together with a CUE is required.

Fieldbus support for these products is shown in the table below.

To create a CIU xxx version, a CIU 900 + CIM xxx interface must be ordered.

CIU unit	Fieldbus protocol	Product numbers	
		CIU 900	CIM
CIU 100	LON	99448387	96824797
CIU 150	PROFIBUS DP		96824793
CIU 200	Modbus RTU		96824796
CIU 260-EU[1]	3G/4G cellular		99439302
CIU 280-EU[2]	Grundfos iSOLUTIONS Cloud/GRM 3G/4G		99439724
CIU 300	BACnet MS/TP		96893770
CIU 500	PROFINET Modbus TCP BACnet IP EtherNet/IP GRM IP		98301408

1) Requires an antenna kit.

2) Grundfos Remote Management (GRM) is an easy-to-install low-cost solution for wireless monitoring and management of Grundfos products. Requires an antenna kit. 3G/4G SIM card must have additional international PDU SMS roaming active

Antennas for CIU 260 and 280

Description	Product number
Antenna kit	99518079

Pt100 sensor, including cable for standard-, N- and R-versions		Cable length [m]	Product number
	GrA3190 0407	20	96913237
		40	96913253
		60	96913256
		80	96913260
		100	96913263

Staybolt kits for Pt100		Description	Product number
	GrA3191 0407	Staybolt kit for Pt100. Material: EN 1.4401/AISI 316.	97550639
		Staybolt kit for Pt100. Material: EN 1.4539/AISI 90L.	96803373

Extension kit for sensor cable for Pt100		Description	Product number
	TM00 7885 2296	Extension kit for Pt100 sensor cable. For watertight shrink-joining of the sensor cable. Extra sensor cable must be ordered separately.	99039717

Sensor cable		Description	Product number
	TM00 7882 2296	Drop cable for extension: 4 x 1 mm^2 Mention length when ordering. Maximum recommended length: 350 m.	00RM5271

MS motor cables

See the following tables for information about additional motor cables.

Drinking water approval

TML-B cables are drinking water compatible with ACS and UBA approvals.

For more information on sizing cables, see *Cable sizing* on page 65.

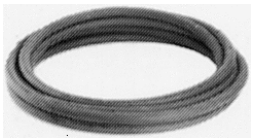
The maximum permissible voltage drop in the motor cable is 3 %.

Always dimension motor cables that are not submerged in the pumped liquid as submersible drop cables.

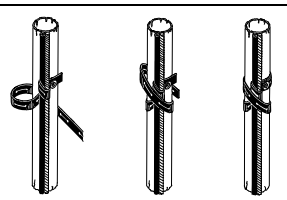
Submersible drop cable

TML-B motor cables EPR outer sheath (ethylene propylene rubber)

Length [m]	Cross-section [mm²]	Product numbers	
		Plug steel grade	Plug steel grade R
10	4G 10.0	96164215	96300124
20		96164216	96300126
30		96164217	96300128
40		99522680	96300129
50		96164218	96300130

Product	Description	Number of leads and nominal cross-section [mm²]	Outer cable diameter min. / max. [mm]	Weight [kg/m]	Product number
 TM00 7882 2296	Suitable for the following applications: • continuous application in groundwater and water (approved for drinking water applications) • connection of electrical equipment, such as submersible motors • installation depths up to 600 metres and average loads. Insulation and sheath of special EPR-based elastomer materials adapted to applications in water. Maximum permissible water temperature: 70 °C. Maximum permissible lead service temperature: 90 °C. Further cable sizes are available on request.	1 x 25	12.5 / 16.5	0.410	00ID4072
		1 x 35	14.0 / 18.5	0.560	00ID4073
		1 x 50	16.5 / 21.0	0.740	00ID4074
		1 x 70	18.5 / 23.5	1.000	00ID4075
		1 x 95	21.0 / 26.5	1.300	00ID4076
		1 x 120	23.5 / 28.5	1.650	00ID4077
		1 x 150	26.0 / 31.5	2.000	00ID4078
		1 x 185	27.5 / 34.5	2.500	00ID4079
		4G1.5	10.5 / 13.5	0.190	00ID4063
		4G2.5	12.5 / 15.5	0.280	00ID4064
		4G4.0	14.5 / 18.0	0.390	00ID4065
		4G6.0	16.5 / 22.0	0.520	00ID4066
		4G10	22.5 / 24.5	0.950	00ID4067
		4G16	26.5 / 28.5	1.400	00ID4068
		4G25	32.0 / 34.0	1.950	00ID4069
		4G35	33.0 / 42.5	2.700	96432949
		4G50	38.0 / 48.5	3.600	96432950
		4G70	43.0 / 54.5	4.900	96432951

Cable clips

Product	Description	Product number
 TM00 1369 5092	For fastening of cable and straining wire to the riser pipe. The clips must be fitted every 3 metres. One set for approximately 45 m riser pipe. • 16 cable buttons. • 7.5 m rubber band.	00115016

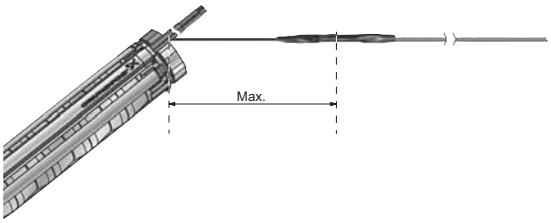
Cable termination kit, type KM

For instruction on how to make the cable termination between motor cable and drop cable, see the KM quick guide available in Grundfos Product Center at http://net.grundfos.com/qr/i/V7065924.

Grundfos recommendation

First termination of motor cable and drop cable should be placed maximum 1/2 meters above the pump end.

Do not attempt to join two cables that have a larger cross-section span than stated in the following table.

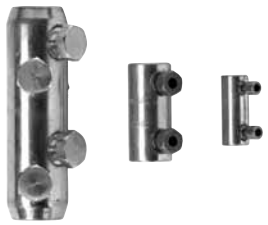


TM06 9876 0817

Motor cable [mm²]	Drop cable, maximum increase per step. [mm²]			
6.0	16.0	35.0	70.0	150.0
10.0	25.0	50.0	120.0	240.0
16.0	50.0	120.0	240.0	-
25.0	70.0	150.0	240.0	-
35.0	70.0	150.0	240.0	-
50.0	120.0	240.0	-	-
70.0	150.0	240.0	-	-

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:			
			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
			KM kits with pressed connections:			
			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
			KM kits with pressed connections:			
			10-70	10-70	1	96828296
			32-120	32-120	1	00116256
			KM kits with screw connectors:			
			90-240	90-240	1	96637279

Note: KM termination kit for single conductors only consist of material for one connection. When ordering, keep in mind how many kits are needed for a complete cable termination.

Product	Description	Version		
		Cross-section of leads [mm²]	Number of connectors	Product number
	Screw connector kit.	6-25	4	96626021
		16-95		96626022
		35-185		96626023
		70-240		96626028

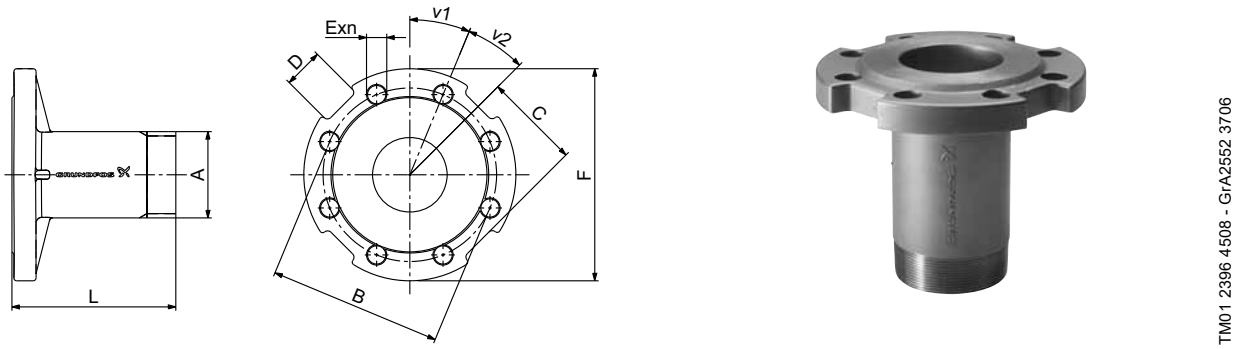
GrA8251 2209

10. Mechanical accessories

Connecting pieces / Adaptors

The tables below show the range of connecting pieces for connection of thread-to-flange and thread-to-thread.

Thread-to-flange (standard flange to EN 1092-1)

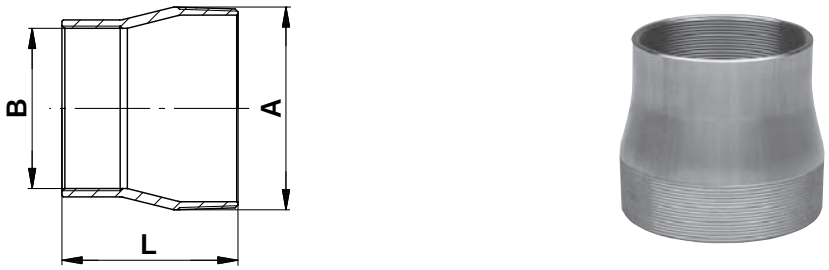


TM01 2396 4508 - GrA2552 3706

Fig. 25 Dimensional sketch and photo of the connecting piece thread-to-flange

Type	Pump outlet	Connecting piece	Thread-to-flange										
			A	Dimensions [mm]						v1	v2	n	Product number
				B	C	D	E	F	L				EN 1.4308 / EN 1.4517
SPE 17	Rp 2 1/2	R 2 1/2 → DN 50 PN 16/40	R 2 1/2	125	65	40	∅19	∅165	170	30	30	4	00120125 / 00120911
		R 2 1/2 → DN 65 PN 16/40	R 2 1/2	145	71	30	∅19	∅185	170	22.5	22.5	8	00120126 / 00120910
		R 2 1/2 → DN 80 PN 16/40	R 2 1/2	160	82.5	40	∅19	∅200	170	22.5	22.5	8	00120127 / 00120909
SPE 30 SPE 46 SPE 60	Rp 3	R 3 → DN 65 PN 16/40	R 3	145	71	30	∅19	∅185	170	22.5	22.5	8	00130187 / 00130920
		R 3 → DN 80 PN 16/40	R 3	160	82.5	40	∅19	∅200	170	22.5	22.5	8	00130188 / 00130921
		R 3 → DN 100 PN 40	R 3	190	100	40	∅23	∅235	170	22.5	22.5	8	00130189 / 00130922
		R 3 → DN 100 PN 16	R 3	180	100	40	∅19	∅220	170	22.5	22.5	8	00130210 / 00130867
SPE 46 SPE 60	Rp 4	R 4 → DN 100 PN 16	R 4	180	100	40	Ø19	Ø235	180	22.5	22.5	8	00140077 / 00140737
		R 4 → DN 100 PN 40	R4	190	100	40	Ø23	Ø235	180	22.5	22.5	8	00140071 / 00140577
SPE 77 SPE 95	Rp 5	R 5 → DN 100 PN 16	R 5	180	82	35	∅19	∅220	195	22.5	22.5	8	00160159 / 00160657
		R 5 → DN 100 PN 40	R 5	190	82	35	∅23	∅235	195	22.5	22.5	8	00160148 / 00160646
		R 5 → DN 125 PN 16	R 5	210	99	37	∅19	∅250	195	22.5	22.5	8	00160157 / 00160655
		R 5 → DN 125 PN 40	R 5	220	99	37	∅28	∅270	195	22.5	22.5	8	00160149 / 00160647
		R 5 → DN 150 PN 16	R 5	240	115	36	∅23	∅285	195	22.5	22.5	8	00160161 / 00160659
		R 5 → DN 150 PN 40	R 5	250	115	36	∅28	∅300	195	22.5	22.5	8	00160150 / 00160648
SPE 125 SPE 160 SPE 215	Rp 6	R 6 → DN 125 PN 16	R 6	210	99	36	∅19	∅250	195	22.5	22.5	8	00170170 / 00170694
		R 6 → DN 125 PN 40	R 6	220	99	36	∅28	∅270	195	22.5	22.5	8	00170159 / 00170596
		R 6 → DN 150 PN 16	R 6	240	114	36	∅23	∅285	195	22.5	22.5	8	98518437 / 98518487
		R 6 → DN 150 PN 40	R 6	250	114	36	∅28	∅300	195	22.5	22.5	8	00170160 / 00170597
		R 6 → DN 200 PN 16	R 6	295	134	36	∅23	∅340	195	15	15	12	00170161 / 00170598
		R 6 → DN 200 PN 40	R 6	320	151	36	∅31	∅375	200	15	15	12	00170162 / 00170599

Thread-to-thread



TM01 2397 4508 - TM06 9783 3317

Fig. 26 Dimensional sketch and photo of a connecting piece thread-to-thread

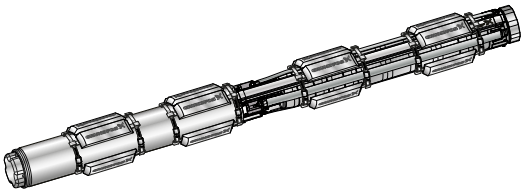
Type	Pump outlet	Connecting piece	Dimensions			Product number		
			Thread-to-thread		L [mm]			
			A	B		EN 1.4301	EN 1.4401	EN 1.4539
SPE 77 SPE 95	Rp 5	R 5 → Rp 4	R 5	Rp 4	121	00190063	00190585	96917293
		R 5 → Rp 6	R 5	Rp 6	150	00190069	00190591	96917296
	5" NPT	5" NPT → 4" NPT	5" NPT	4" NPT	121	00190064	00190586	00190964
		5" NPT → 6" NPT	5" NPT	6" NPT	150	00190070	00190592	00190965
SPE 125 SPE 160 SPE 215	Rp 6	R 6 → Rp 5	R 6	Rp 5	150	00200130	00200640	00200971
	6" NPT	6" NPT → 5" NPT	6" NPT	5" NPT	150	00200135	00200645	00200970

Zinc anodes

Applications

Cathodic protection by zinc anodes can be used for corrosion protection of SPE pumps in chloride-containing liquids, such as brackish water and seawater.

Sacrificial anodes are placed on the outside of the pump and motor as protection against corrosion. See fig. 27.



TM07 6115 0820

Fig. 27 Submersible motor fitted with anode strings

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

Contact Grundfos for further details.

More information about zinc anodes and product numbers are available in SPE accessories data booklet and on *Grundfos Product Center*: https://product-selection.grundfos.com.

Flow sleeves

Grundfos offers a complete range of stainless-steel flow sleeves for both vertical and horizontal operation. We recommend flow sleeves for all applications in which motor cooling is insufficient. The result is a general extension of motor life. Flow sleeves are to be fitted in the following cases:

- If the submersible pump is exposed to a high thermal load such as current unbalance, dry running, overload, high ambient temperature, and bad cooling conditions.
- If aggressive liquids are pumped, since corrosion is doubled for every 10 °C the temperature rises.
- If sedimentation or deposits occur around and/or on the motor.

More information about flow sleeves and product numbers are available in SPE accessories data booklet and on *Grundfos Product Center*.

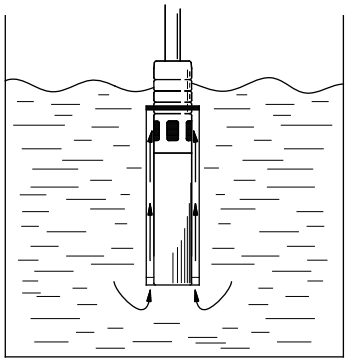
https://product-selection.grundfos.com.

TM01 0751 2197 - TM01 0750 2197

Fig. 28 Flow sleeves

Example of calculated flow sleeve

The flow sleeve is fitted to the submersible motor so that the liquid passes close by the motor on its way towards the pump suction interconnector, thus ensuring optimum cooling of the motor. See fig. 29.



TM01 0509 1297

Fig. 29 Flow sleeve function

The flow sleeve is designed so that the flow velocity past the motor is minimum 0.5 m/s and maximum 3 m/s to ensure optimum pump operating conditions.

Use the following formula to calculate the flow velocity:

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

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

11. Certificates

Grundfos SPE offers a number of certificates and reports.

In case a certificate or a report is needed, the request must be stated on the order.

The certificate or the report is then put into the bill of materials and included in the product documentation.

Certificates or reports have to be confirmed for every order.

SPE certificates

Part number	Description
96507896	Test certificate non- specified. Inspec+test
96507897	Inspection certificate internal
96699829	Inspection certificate 3rd party
96507928	Material specification report
96507934	Cleaned and dried pump report
96507895	Certificate of compliance with the order
96507930	Report Pump curve test - Grade 3B

ISO 9906:2012 test report

Part number	Test report title
98578602 + 96539699	Witness test + Duty point verification report - Grade 3B, Q&H
96539699	Duty point verification report - Grade 3B, Q&H
99542665	Duty point verification report - Grade 3B, Q&H+eta total
99542666	Duty point verification report - Grade 3B, Q&H+P1
98578602 + 98777781	Witness test + Duty point verification report - Grade 2B, Q&H
98777781	Duty point verification report - Grade 2B, Q&H
99542667	Duty point verification report - Grade 2B, Q&H+eta total
99542668	Duty point verification report - Grade 2B, Q&H+P1
98578602+ 99542669	Witness test + Duty point verification report - Grade 2U, Q&H
99542669	Duty point verification report - Grade 2U, Q&H
99542670	Duty point verification report - Grade 2U, Q&H+eta total
99542671	Duty point verification report - Grade 2U, Q&H+P1
98578602+ 99542672	Witness test + Duty point verification report - Grade 1B, Q&H
99542672	Duty point verification report - Grade 1B, Q&H
99542673	Duty point verification report - Grade 1B, Q&H+eta total
99542675	Duty point verification report - Grade 1B, Q&H+P1
98578602+ 99542676	Witness test + Duty point verification report - Grade 1E, Q&H
99542676	Duty point verification report - Grade 1E, Q&H
99542677	Duty point verification report - Grade 1E, Q&H+eta total
99542678	Duty point verification report - Grade 1E, Q&H+P1
98578602+ 99542680	Witness test + Duty point verification report - Grade 1U, Q&H
99542680	Duty point verification report - Grade 1U, Q&H
99542682	Duty point verification report - Grade 1U, Q&H+eta total
99542693	Duty point verification report - Grade 1U, Q&H+P1

ISO 9906:2012 tolerance factors

	Grade 1			Grade 2		Grade 3	
	1U	1E	1B	2B	2U	3B	
Flow rate [τ_Q]	+ 10 %	± 5 %	± 5 %	± 8 %	± 16 %	± 9 %	Mandatory
Head [τ_H]	+ 6 %	± 3 %	± 3 %	± 5 %	± 10 %	± 7 %	
Efficiency [τ_η]	≥ 0 %	≥ 0 %	- 3 %	- 5 %	- 5 %	- 7 %	Optional

Example of certificate

Test certificate non- specified. Inspec+test

BE THINK INNOVATE — GRUNDFOS

Test certificate
Non-specific inspection and testing

EN 10204 2.2

Customer name	
Customer order no.	
Customer TAG no.	
GRUNDFOS order no.	

Pump		
Pump type		Part number
Motor make		Part number
Flow	m^3/h	
Head	m	
Power P2	kW	
Voltage	V	
Frequency	Hz	
Full load current	A	
Motor speed	min^{-1}	

We the undersigned hereby guarantee and certify that the materials and/or parts for the above mentioned product were manufactured, tested, inspected, and conform to the full requirements of the appropriate catalogues, drawings and / or specifications relative thereto.

GRUNDFOS
Date:

Signature:
Name:
Dept.:

Part no 96 50 78 96/1001002

TM034163 1706

Inspection certificate internal

Inspection Certificate

Type EN 10204 3.1

General Info			
Customer name			
Customer order no.		GRUNDFOS order no.	
Customer TAG no.			
Ship / new building			
Shipyard / factory			

Pump		Motor	
Pump type		Make	
Part No.		Part No.	
Serial No.		Serial No.	
Model		P2 [kW]	
Flow rate [m^3/h]		Voltage [V]	
Head [m]		Current [A]	
Max. liquid temp [°C]		Motor speed [min^{-1}]	
Max. opr. Press. [bar]		Frequency [Hz]	
		IP code	
		Max. temp. amb. [°C]	

Required duty point			
Flow rate [m^3/h]		Head [m]	

Test performance
Result of tests are attached. See test point

GRUNDFOS
Date:

Signature:
Name:
Dept.:

be think innovate — GRUNDFOS

Part no. 96507897/PMI/000/1252874

TM060200 5013

Inspection certificate 3rd party

Inspection certificate 3.1/3.2 (Annex A)
EN 10204

Complete pump :

Customer name	
Customer order no.	
Manufactured by	Grundfos A/S - DK
Grundfos order no.	

Pump		Motor	
Pump type		Make	
Part number		Part number	
Serial number		Serial number	
Flow rate (m^3/h)		P2 (kW)	
Head (m)		Voltage (V)	
	Din / EN	Current (A)	
Chamber		n (min^{-1})	
Impeller		Frequency (Hz)	
Shaft		Insulation class	
Suction Interconnector		Power factor	
Valve casing			
Straps			

Costumer's requirements			
Flow rate (m^3/h)		Head (m)	

Test result ref. requirements. According to ISO9906, Annex A									
Q(m^3/h)		H(m)		n(min^{-1})		I(A)		P1(kW)	

The pump has been marked	
Inspected by	

Surveyor signature:

Tested date:

GRUNDFOS
Date:

Signature:
Name:
Dept.:

Part no 96699829

be think innovate — GRUNDFOS

TM073153 4718

Material specification report

BE THINK INNOVATE — GRUNDFOS

Material specification report.

Customer name	
Customer order no.	
Customer TAG no.	
GRUNDFOS order no.	
Pump type	
GRUNDFOS DUT id.	
Part number	
Production code	

Pump	Materials	DIN W.-Nr.	AISI / ASTM
Pump head			
Pump head cover			
Shaft			
Impeller			
Chamber			
Outer sleeve			
Base			

We the undersigned hereby guarantee and certify that the materials and/or parts for the above mentioned product were manufactured, tested, inspected, and conform to the full requirements of the appropriate catalogues, drawings and/or specifications relative thereto.

GRUNDFOS
Date:

Signature:
Name:
Dept.:

Part no 96 50 79 28/A72775

TM034150 1706

Cleaned and dried pump report

BE › THINK › INNOVATE › GRUNDFOS

Cleaned and dried pump

Customer name	
Customer order no.	
Customer TAG no.	
GRUNDFOS order no.	
Pump type	
GRUNDFOS DUT id.	
Part number	
Production code	

GRUNDFOS hereby confirms that the pump mentioned above is manufactured according the specifications mentioned in the "CR, CRI, CRN Custom-built pumps" data booklet. This means that prior to assembly, pump components are washed in pure, hot soap water, rinsed in de-ionized water and dried.

The pump is wrapped in a plastic bag before being packed.

The pump has not been performance-tested.

GRUNDFOS
Date:

Signature:
Name:
Dept.:

Part no 96 50 79 34/A72775

TM034145 1706

Certificate of compliance with the order

BE › THINK › INNOVATE › GRUNDFOS

Certificate of compliance with the order

EN 10204 2.1

Customer name	
Customer order no.	
Customer Tag no.	
GRUNDFOS order no.	
Product type	

We the undersigned hereby guarantee and certify that the materials and/or parts for the above mentioned product were manufactured, tested, inspected, and conform to the full requirements of the appropriate catalogues, drawings and/or specifications relative thereto.

GRUNDFOS
Date:

Signature:
Name:
Dept.:

Part no. 96 50 78 95/1001002

TM034165 1706

Example of test report

ISO 9906:2012 test report - F. SPE pump Grade 3B

Test Report for SP Pump

ISO 9906: 2012 Grade 3B

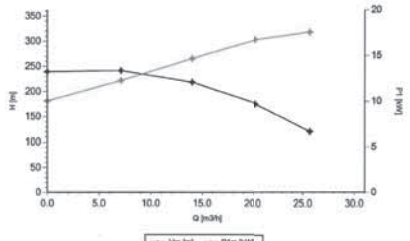
Customer:
Order Number:
Operator:
Certificate Part Number: 96643427

Serial number: 98357225p312410001
Date: 18/10/2012 13:38
Testbed: 508276

Pump type: SP1715 RP 2 1/2
Product Number: 98357225

Motor manufacturer MS60 00

Measured values for tested pump



Result:

	Qm [m3/h]	Hm [m]	n [1/min]	η_total [%]	EtaQ [kWh/m3/h]	EtaQH [kWh/m/h/ton]
Point 1	25.67	121.05	3457	48	0.68	0.0067
Point 2	20.32	176.02	3463	58	0.82	0.0047
Point 3	14.02	218.39	3479	57	1.05	0.0048
Point 4	7.13	241.53	3500	38	1.72	0.0071
Point 5	0.00	239.45	3519	0	0.00	0

	U1 [V]	U2 [V]	U3 [V]	f [Hz]	I_Avg [A]	I1 [A]	I2 [A]	I3 [A]	Cos(ϕ)	P1m [kW]
Point 1	441.0	439.0	439.0	60	26.78	27.04	26.94	26.35	0.86	17.56
Point 2	441.0	439.0	440.0	60	25.64	25.82	25.81	25.30	0.86	16.79
Point 3	440.0	439.0	439.0	60	22.81	22.89	22.92	22.51	0.84	14.65
Point 4	441.0	439.0	440.0	60	19.67	19.90	19.61	19.49	0.81	12.23
Point 5	440.0	439.0	440.0	60	16.92	17.03	16.86	16.88	0.78	10.01

Page 1 of 3

GRUNDFOS

TM07 2188 4718

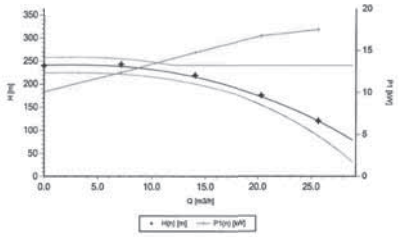
Test Report for SP Pump

ISO 9906: 2012 Grade 3B

Customer:
Order Number:
Operator:
Certificate Part Number: 96643427

Serial number: 98357225p312410001
Date: 18/10/2012 13:38
Testbed: 508276

Measured values calculated to nominal speed n_nom



Result:

	Q(n) [m3/h]	H(n) [m]	P1(n) [kW]	n_nom [1/min]
Point 1	25.63	120.75	17.50	3452.83
Point 2	20.32	176.00	16.75	3462.9
Point 3	14.04	219.12	14.73	3484.89
Point 4	7.15	242.99	12.35	3510.51
Point 5	0.00	240.16	10.06	3524.24

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GRUNDFOS

TM07 2189 4718

Test Report for SP Pump

ISO 9906: 2012 Grade 3B

Customer:
Order Number:
Operator:
Certificate Part Number: 96643427

Serial number: 98357225p312410001
Date: 18/10/2012 13:38
Testbed: 508276

Measured values

U	=	Voltage	Cos(ϕ)	=	Power factor
f	=	Frequency	n	=	Speed
I_Avg	=	Average current			
Qm	=	Measured flow			
Hm	=	Measured Total Head			
P1m	=	Measured Motor Power Input			

Calculated values

Q(n)	=	Flow at nominal speed	η_total	=	Total Efficiency
H(n)	=	Total Head at nominal speed	η_pump	=	Pump efficiency
P1(n)	=	Motor Power Input at nominal speed	EtaQ	=	Specific energy consumption
			EtaQH	=	Specific energy consumption

Formulas

Q(n)	=	Qm x (n_nom/n)	H	=	Head_Sta + Head_Dyn + Head_Geo + Head_f
H(n)	=	Hm x (n_nom/n)²	Head_Static	=	Static Pressure head
P1(n)	=	P1m x (n_nom/n)³	Head_Dyn	=	Dynamic head
η_total	=	(g x Qm x Hm x ρ) / P1m	Head_Geo	=	Geometric elevation head
η_pump	=	η_total / η_motor	Head_f	=	Friction head
EtaQ	=	P1m / Qm	EtaQH	=	P1m / Qm / Hm

Legend and test conditions:

- Measurements were made with tapwater at approximately 20 °C and a kinematic viscosity of 1mm²/s (= 1 cSt)
- The test bed is calibrated according to ISO 9001

Calibration Date:

Test Facility:

Grundfos Danmark
GL. Viborgvej 79
Aalestrup
9620
Danmark
Phone:
Fax:

Tested Date

Signed by

24/01/2013 13:02:04
www.grundfos.com

Page 3 of 3

GRUNDFOS

TM07 2190 4718

12. Cable sizing

Cables

Grundfos offers 4-core cable and single conductors as submersible drop cables for all applications. The submersible drop cable is chosen according to application and type of installation. See *Submersible drop cable* on page 56.

Tables indicating cable dimension in borehole

The tables indicate the maximum length of drop cables in metres from motor starter to pump at direct-on-line starting at different cable dimensions.

If, for example, the operating current is 10 % lower than the full-load current, the cable can be 10 % longer than indicated in the tables.

The calculation of the cable length is based on a maximum voltage drop of 1 % to 3 % of the rated voltage and a water temperature of maximum 30 °C.

In order to minimise operating losses, the cable cross-section may be increased compared to what is indicated in the tables. This is only economical if the following apply:

- Borehole provides the necessary space.
- Operational time of the pump is long.
- Operating voltage is below the rated voltage.

A cable sizing tool is available on Grundfos insite at https://www.grundfos.com/sp-system/download-sp-app.html.

TM07 6259 1220

Fig. 30 Cable sizing tool

The values of the cable sizing tool are calculated on the basis of the formula for maximum cable length for a three-phase submersible pump.

Formula:

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

A prerequisite for using the formulas is that the current is sinusoidal, which requires the use of a working sine wave filter.

Formula designations

U = Rated voltage [V]

ΔU = Voltage drop [%]

I = Rated current of the VFD [A]

cos φ = Power factor

ρ = Specific resistance: 0.025 [Ω mm^2]

q = Cross-section of submersible drop cable [mm^2]

sin φ = $\sqrt{1 - \cos^2\varphi}$

X_L = Inductive resistance: 0.078 x 10^{-3} [Ω/m].

Example

Motor size:	30 kW, MS6000P
Starting method:	Direct on line
Rated voltage (U):	3 x 380 V
Voltage drop (ΔU):	3 %
Rated current (I):	64.0 A
Power factor (cos φ):	0.90
Specific resistance (ρ):	0.025
Cross-section (q):	25 mm^2
sin φ:	0.54
Inductive resistance (X_L):	0.078 x 10^{-3} [Ω/m]

$$L = \frac{380 \times 3}{64.0 \times 1.73 \times 100 \times (0.909 \times \frac{0.025}{25} + 0.54 \times 0.078 \times 10^{-3})}$$

L = 112 m.

Calculation of cable cross-section

Formula designations

U = Rated voltage [V]
ΔU = Voltage drop [%]
I = Rated current of the VFD [A]
cos φ = Power factor
ρ = 1/χ
Materials of cable:
Copper: χ = 40 m/Ω x mm^2
q = Cross-section [mm^2]
sin φ = $\sqrt{1 - \cos^2\varphi}$
X_L = Inductive resistance 0.078 x 10^{-3} [Ω/m]
L = Length of cable [m]
Δp = Power loss [W].

For calculation of the cross-section of the submersible drop cable, use the following formulas:

Single plug motor

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

Two-plug motor

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

The values of the rated current (I) and the power factor (cos φ) are shown in the tables on page 67.

Calculation of the power loss

For calculation of the power loss in the submersible drop cable, use the following formula:

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

Example

Motor size:	30 kW MS6000P
Voltage:	3 x 380 V, 50 Hz
Starting method:	Direct on line
Rated current (I_n):	64.0 A
Required cable length (L):	112 m
Water temperature:	30 °C.

Cable selection

Choice A: 3 x 25 mm^2.
Choice B: 3 x 35 mm^2.

Calculation of power loss

Choice A

$$\Delta p_A = \frac{3 \times L \times \rho \times I^2}{q}$$

$$\Delta p_A = \frac{3 \times 112 \times 0.02 \times 64.0^2}{25}$$

Δp_A = 1101 W.

Choice B

$$\Delta p_B = \frac{3 \times 112 \times 0.02 \times 64.0^2}{35}$$

Δp_B = 786 W.

Savings

Operating hours/year: h = 4000.

Annual saving (A):

A = (Δp_A - Δp_B) x h = (1101 W - 786 W) x 4000 = 1260000 Wh = 1260 kWh.

By choosing the cable size 3 x 35 mm^2 instead of 3 x 25 mm^2, an annual saving of 1260 kWh can be achieved.

Operating time: 10 years.

Saving after 10 years (A_{10}):

A_{10} = A x 10 = 1260 x 10 = 12600 kWh.

The saved amount must be calculated in the local currency.

Cable dimensions at 3 x 380 V, 100 Hz motor supply, valid for use of TML-B cables.

Voltage drop: 3 % at 30 °C ambient temperature

Motor	kW	I_n [A]	Cos φ 100 %	Dimensions [mm²]														
				1.5	2.5	4	6	10	16	25	35	50	70	95	120	150	185	240	300
6"	4	9.6	0.95	55	91	146	218	359	566	867									
6"	5.5	12.6	0.92	40	66	105	157	258	407	622	850								
6"	7.5	16.6	0.88	29	49	78	117	193	304	465	637	882							
6"	9.2	21.4	0.94	23	39	62	93	154	243	372	510	706	950						
6"	11	25.0	0.93		34	53	80	132	209	320	440	610	823						
6"	13	29.2	0.92		28	45	68	112	176	270	370	513	690	893					
6"	15	33.4	0.88			39	59	97	154	236	324	449	604	783	947				
6"	18.5	40.6	0.88				48	80	126	193	265	366	493	638	770	914			
6"	22	46.2	0.91				41	67	107	164	225	313	422	549	665	793	927		
6"	26	54.0	0.90					57	90	138	189	263	355	462	560	667	781	937	
6"	30	61.8	0.90					49	78	119	164	227	307	398	482	574	670	803	926
6"	37	85.6	0.86						63	97	133	183	246	317	382	452	525	624	714
6"	45	103.0	0.85																
Max. current for cable [A] at 30 °C ambient temperature[1)]				23	30	41	53	74	99	131	162	202	250	301	352	404	461	547	633

1) At particularly favourable heat dissipation conditions. Maximum cable length in metres from motor starter to pump.
For motors with parallel cabling, the cable length can be calculated by multiplying the relevant cable length from the above table by $\sqrt{3}$.

13. Table of head losses

Head losses in ordinary water pipes

Upper figures indicate the velocity of water in m/sec.

Lower figures indicate head loss in metres per 100 metres of straight pipes.

Quantity of water			Head losses in ordinary water pipes											
			Nominal pipe diameter in inches and internal diameter in [mm]											
m^3/h	Litres/min.	Litres/sec.	1/2" 15.75	3/4" 21.25	1" 27.00	1 1/4" 35.75	1 1/2" 41.25	2" 52.50	2 1/2" 68.00	3" 80.25	3 1/2" 92.50	4" 105.0	5" 130.0	6" 155.5
0.6	10	0.16	0.855 9.910	0.470 2.407	0.292 0.784									
0.9	15	0.25	1.282 20.11	0.705 4.862	0.438 1.570	0.249 0.416								
1.2	20	0.33	1.710 33.53	0.940 8.035	0.584 2.588	0.331 0.677	0.249 0.346							
1.5	25	0.42	2.138 49.93	1.174 11.91	0.730 3.834	0.415 1.004	0.312 0.510							
1.8	30	0.50	2.565 69.34	1.409 16.50	0.876 5.277	0.498 1.379	0.374 0.700	0.231 0.223						
2.1	35	0.58	2.993 91.54	1.644 21.75	1.022 6.949	0.581 1.811	0.436 0.914	0.269 0.291						
2.4	40	0.67		1.879 27.66	1.168 8.820	0.664 2.290	0.499 1.160	0.308 0.368						
3.0	50	0.83		2.349 41.40	1.460 13.14	0.830 3.403	0.623 1.719	0.385 0.544	0.229 0.159					
3.6	60	1.00		2.819 57.74	1.751 18.28	0.996 4.718	0.748 2.375	0.462 0.751	0.275 0.218					
4.2	70	1.12		3.288 76.49	2.043 24.18	1.162 6.231	0.873 3.132	0.539 0.988	0.321 0.287	0.231 0.131				
4.8	80	1.33			2.335 30.87	1.328 7.940	0.997 3.988	0.616 1.254	0.367 0.363	0.263 6.164				
5.4	90	1.50			2.627 38.30	1.494 9.828	1.122 4.927	0.693 1.551	0.413 0.449	0.269 0.203				
6.0	100	1.67			2.919 46.49	1.660 11.90	1.247 5.972	0.770 1.875	0.459 0.542	0.329 0.244	0.248 0.124			
7.5	125	2.08			3.649 70.41	2.075 17.93	1.558 8.967	0.962 2.802	0.574 0.809	0.412 0.365	0.310 0.185	0.241 0.101		
9.0	150	2.50				2.490 25.11	1.870 12.53	1.154 3.903	0.668 1.124	0.494 0.506	0.372 0.256	0.289 0.140		
10.5	175	2.92				2.904 33.32	2.182 16.66	1.347 5.179	0.803 1.488	0.576 0.670	0.434 0.338	0.337 0.184		
12	200	3.33				3.319 42.75	2.493 21.36	1.539 6.624	0.918 1.901	0.659 0.855	0.496 0.431	0.385 0.234	0.251 0.084	
15	250	4.17				4.149 64.86	3.117 32.32	1.924 10.03	1.147 2.860	0.823 1.282	0.620 0.646	0.481 0.350	0.314 0.126	
18	300	5.00					3.740 45.52	2.309 14.04	1.377 4.009	0.988 1.792	0.744 0.903	0.577 0.488	0.377 0.175	0.263 0.074
24	400	6.67					4.987 78.17	3.078 24.04	1.836 6.828	1.317 3.053	0.992 1.530	0.770 0.829	0.502 0.294	0.351 0.124
30	500	8.33						3.848 36.71	2.295 10.40	1.647 4.622	1.240 2.315	0.962 1.254	0.628 0.445	0.439 0.187
36	600	10.0						4.618 51.84	2.753 14.62	1.976 6.505	1.488 3.261	1.155 1.757	0.753 0.623	0.526 0.260
42	700	11.7							3.212 19.52	2.306 8.693	1.736 4.356	1.347 2.345	0.879 0.831	0.614 0.347
48	800	13.3							3.671 25.20	2.635 11.18	1.984 5.582	1.540 3.009	1.005 1.066	0.702 0.445
54	900	15.0							4.130 31.51	2.964 13.97	2.232 6.983	1.732 3.762	1.130 1.328	0.790 0.555
60	1000	16.7							4.589 38.43	3.294 17.06	2.480 8.521	1.925 4.595	1.256 1.616	0.877 0.674
75	1250	20.8								4.117 26.10	3.100 13.00	2.406 7.010	1.570 2.458	1.097 1.027
90	1500	25.0								4.941 36.97	3.720 18.42	2.887 9.892	1.883 3.468	1.316 1.444
105	1750	29.2									4.340 24.76	3.368 13.30	2.197 4.665	1.535 1.934
120	2000	33.3									4.960 31.94	3.850 17.16	2.511 5.995	1.754 2.496
150	2500	41.7										4.812 26.26	3.139 9.216	2.193 3.807
180	3000	50.0											3.767 13.05	2.632 5.417
240	4000	66.7											5.023 22.72	3.509 8.926
300	5000	83.3												4.386 14.42
90 ° bends, slide valves			1.0	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.6	1.7	2.0	2.5
T-pieces, non-return valves			4.0	4.0	4.0	5.0	5.0	5.0	6.0	6.0	6.0	7.0	8.0	9.0

The table is calculated in according to H. Lang's new formula a = 0.02 and for a water temperature of 10 °C.
The head loss in bends, slide valves, T-pieces and non-return valves is equivalent to the metres of straight pipes stated in the last two lines of the table.
To find the head loss in foot valves, multiply the loss in T-pieces by two.

Head losses in plastic pipes

Upper figures indicate the velocity of water in m/sec.

Lower figures indicate head loss in metres per 100 metres of straight pipes.

Quantity of water			PELM/PEH PN 10											
			PELM						PEH					
m^3/h	Litres/min.	Litres/sec.	25 20.4	32 26.2	40 32.6	50 40.8	63 51.4	75 61.4	90 73.6	110 90.0	125 102.2	140 114.6	160 130.8	180 147.2
0.6	10	0.16	0.49 1.8	0.30 0.66	0.19 0.27	0.12 0.085								
0.9	15	0.25	0.76 4.0	0.46 1.14	0.3 0.6	0.19 0.18	0.12 0.63							
1.2	20	0.33	1.0 6.4	0.61 2.2	0.39 0.9	0.25 0.28	0.16 0.11							
1.5	25	0.42	1.3 10.0	0.78 3.5	0.5 1.4	0.32 0.43	0.2 0.17	0.14 0.074						
1.8	30	0.50	1.53 13.0	0.93 4.6	0.6 1.9	0.38 0.57	0.24 0.22	0.17 0.092						
2.1	35	0.58	1.77 16.0	1.08 6.0	0.69 2.0	0.44 0.70	0.28 0.27	0.2 0.12						
2.4	40	0.67	2.05 22.0	1.24 7.5	0.80 3.3	0.51 0.93	0.32 0.35	0.23 0.16	0.16 0.063					
3.0	50	0.83	2.54 37.0	1.54 11.0	0.99 4.8	0.63 1.40	0.4 0.50	0.28 0.22	0.2 0.09					
3.6	60	1.00	3.06 43.0	1.85 15.0	1.2 6.5	0.76 1.90	0.48 0.70	0.34 0.32	0.24 0.13	0.16 0.050				
4.2	70	1.12	3.43 50.0	2.08 18.0	1.34 8.0	0.86 2.50	0.54 0.83	0.38 0.38	0.26 0.17	0.18 0.068				
4.8	80	1.33		2.47 25.0	1.59 10.5	1.02 3.00	0.64 1.20	0.45 0.50	0.31 0.22	0.2 0.084				
5.4	90	1.50		2.78 30.0	1.8 12.0	1.15 3.50	0.72 1.30	0.51 0.57	0.35 0.26	0.24 0.092	0.18 0.05			
6.0	100	1.67		3.1 39.0	2.0 16.0	1.28 4.6	0.8 1.80	0.56 0.73	0.39 0.30	0.26 0.12	0.2 0.07			
7.5	125	2.08		3.86 50.0	2.49 24.0	1.59 6.6	1.00 2.50	0.70 1.10	0.49 0.50	0.33 0.18	0.25 0.10	0.20 0.055		
9.0	150	2.50			3.00 33.0	1.91 8.6	1.20 3.5	0.84 1.40	0.59 0.63	0.39 0.24	0.30 0.13	0.24 0.075		
10.5	175	2.92			3.5 38.0	2.23 11.0	1.41 4.3	0.99 1.80	0.69 0.78	0.46 0.30	0.36 0.18	0.28 0.09		
12	200	3.33			3.99 50.0	2.55 14.0	1.60 5.5	1.12 2.40	0.78 1.0	0.52 0.40	0.41 0.22	0.32 0.12	0.25 0.065	
15	250	4.17				3.19 21.0	2.01 8.0	1.41 3.70	0.98 1.50	0.66 0.57	0.51 0.34	0.40 0.18	0.31 0.105	0.25 0.06
18	300	5.00				3.82 28.0	2.41 10.5	1.69 4.60	1.18 1.95	0.78 0.77	0.61 0.45	0.48 0.25	0.37 0.13	0.29 0.085
24	400	6.67					3.21 19.0	2.25 8.0	1.57 3.60	1.05 1.40	0.81 0.78	0.65 0.44	0.50 0.23	0.39 0.15
30	500	8.33					4.01 28.0	2.81 11.5	1.96 5.0	1.31 2.0	1.02 1.20	0.81 0.63	0.62 0.33	0.49 0.21
36	600	10.0					4.82 37.0	3.38 15.0	2.35 6.6	1.57 2.60	1.22 1.50	0.97 0.82	0.74 0.45	0.59 0.28
42	700	11.7					5.64 47.0	3.95 24.0	2.75 8.0	1.84 3.50	1.43 1.90	1.13 1.10	0.87 0.60	0.69 0.40
48	800	13.3						4.49 26.0	3.13 11.0	2.09 4.5	1.62 2.60	1.29 1.40	0.99 0.81	0.78 0.48
54	900	15.0						5.07 33.0	3.53 13.5	2.36 5.5	1.83 3.20	1.45 1.70	1.12 0.95	0.08 0.58
60	1000	16.7						5.64 40.0	3.93 16.0	2.63 6.7	2.04 3.90	1.62 2.2	1.24 1.2	0.96 0.75
75	1250	20.8							4.89 25.0	3.27 9.0	2.54 5.0	2.02 3.0	1.55 1.6	1.22 0.95
90	1500	25.0							5.88 33.0	3.93 13.0	3.05 8.0	2.42 4.1	1.86 2.3	1.47 1.40
105	1750	29.2							6.86 44.0	4.59 17.5	3.56 9.7	2.83 5.7	2.17 3.2	1.72 1.9
120	2000	33.3								5.23 23.0	4.06 13.0	3.23 7.0	2.48 4.0	1.96 2.4
150	2500	41.7								6.55 34.0	5.08 18.0	4.04 10.5	3.10 6.0	2.45 3.5
180	3000	50.0								7.86 45.0	6.1 27.0	4.85 14.0	3.72 7.6	2.94 4.4
240	4000	66.7									8.13 43.0	6.47 24.0	4.96 13.0	3.92 7.5
300	5000	83.3										8.08 33.0	6.2 18.0	4.89 11.0

The table is based on a nomogram.
Roughness: K = 0.01 mm.
Water temperature: t = 10 °C.

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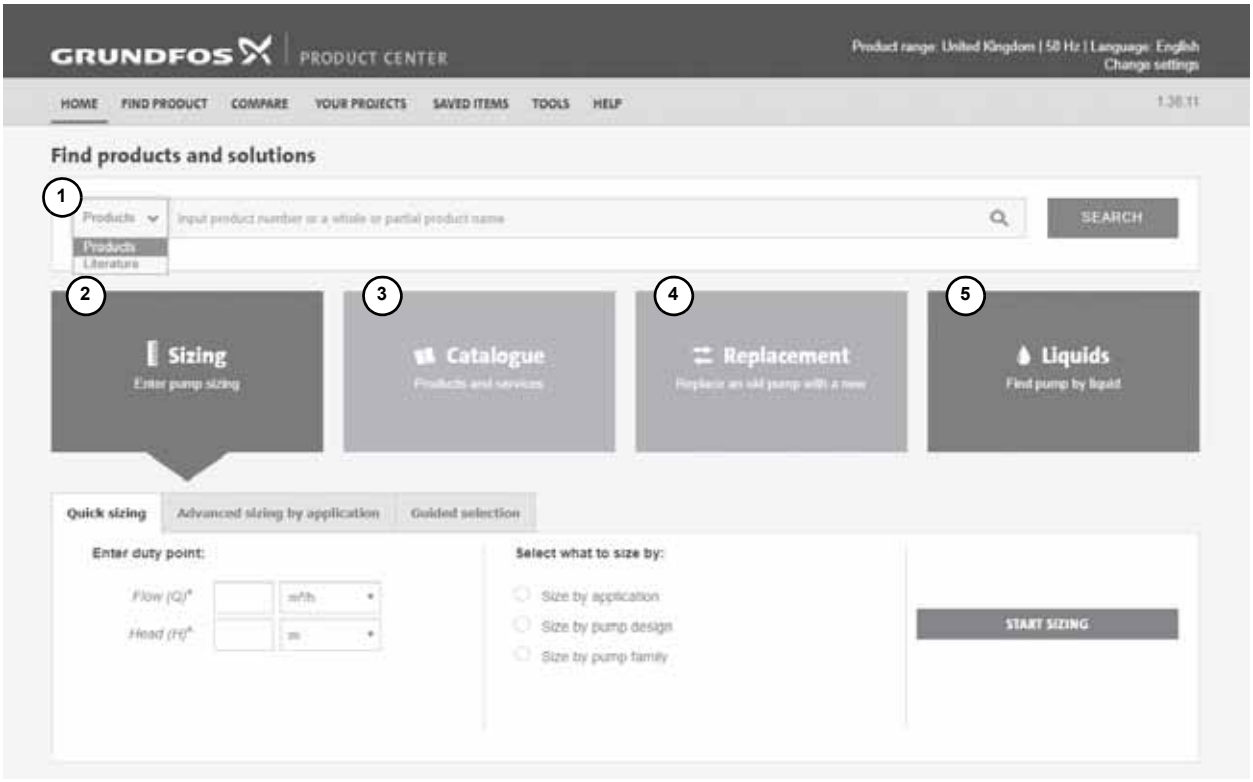

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GRUNDFOS A/S
DK-8850 Bjerringbro . Denmark
Telephone: +45 87 50 14 00
www.grundfos.com

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