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.

The table is calculated in accordance with 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.

Quantity of water			Head losses in ordinary water pipes									
			Nominal pipe diameter in inches and internal diameter in [mm]									
m3/h	Litres/min.	Litres/sec.	1" 27.00	1¼" 35.75	1½" 41.25	2" 52.50	2½" 68.00	3" 80.25	3½" 92.50	4" 105.0	5" 130.0	6" 155.5
3.0	50	0.83	1.460 13.14	0.830 3.403	0.623 1.719	0.385 0.544	0.229 0.159					
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			
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		
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			1.1	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	5.0	5.0	5.0	6.0	6.0	6.0	7.0	8.0	9.0

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GRUNDFOS Holding A/S
Poul Due Jensens Vej 7
DK-8850 Bjerringbro
Tel: +45 87 50 14 00
www.grundfos.com

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QUICK GUIDE
to safe installation

GET THE FULL VALUE

OF YOUR SUBMERSIBLE PUMP SYSTEM

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Cable dimensions in mm²									
25	35	50	70	95	120	150	185	240	300
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-
853	-	-	-	-	-	-	-	-	-
624	855	-	-	-	-	-	-	-	-
445	609	841	-	-	-	-	-	-	-
867	-	-	-	-	-	-	-	-	-
622	850	-	-	-	-	-	-	-	-
465	637	882	-	-	-	-	-	-	-
372	510	706	950	-	-	-	-	-	-
320	440	610	823	-	-	-	-	-	-
270	370	513	690	893	-	-	-	-	-
236	324	449	604	783	947	-	-	-	-
193	265	366	493	638	770	914	-	-	-
164	225	313	422	549	665	793	927	-	-
138	189	263	355	462	560	667	781	937	-
119	164	227	307	398	482	574	670	803	926
97	133	183	246	317	382	452	525	624	714
164	225	313	422	549	665	793	927	-	-
138	189	263	356	464	563	672	787	947	-
122	167	233	314	409	497	593	695	836	968
99	136	190	256	334	405	483	567	682	789
83	114	158	213	276	334	396	462	553	636
68	94	131	177	230	279	333	390	469	544
-	83	115	155	201	243	289	338	404	466
-	70	97	132	171	208	249	292	353	409
-	-	79	107	140	170	204	239	288	335
-	-	-	89	116	141	169	198	240	279
-	69	96	130	169	205	244	285	343	396
-	-	79	106	137	166	197	230	275	316
-	-	-	89	116	140	167	195	234	271
-	-	-	-	98	118	141	165	198	229
-	-	-	-	-	103	122	142	169	194
-	-	-	-	-	-	105	122	146	168
-	-	-	-	-	-	-	106	125	144
-	-	-	-	-	105	125	146	175	202
-	-	-	-	-	92	110	129	155	180
-	-	-	-	-	-	98	114	137	158
-	-	-	-	-	-	-	100	120	139
-	-	-	-	-	-	-	-	106	123
131	162	202	250	301	352	404	461	547	633

Cable dimensions for submersible motors at 3 x 400 V, star-delta starting.
Voltage drop 3%

Motor	kW	[A]	Cos 100%	Cable dimensions in mm²															
				1,5	2,5	4	6	10	16	25	35	50	70	95	120	150	185	240	300
6"	4	9,2	0,82	95	158	252	377	623	984	-	-	-	-	-	-	-	-	-	-
6"	5,5	13,6	0,77	68	114	181	271	447	704	-	-	-	-	-	-	-	-	-	-
6"	7,5	17,6	0,8	51	85	135	202	333	526	805	-	-	-	-	-	-	-	-	-
6"	9,2	21,8	0,81	41	68	108	161	266	420	643	882	-	-	-	-	-	-	-	-
6"	11	24,8	0,83	-	58	93	138	228	361	554	760	-	-	-	-	-	-	-	-
6"	13	30	0,81	-	49	78	117	193	305	467	641	887	-	-	-	-	-	-	-
6"	15	34	0,82	-	-	68	102	168	266	408	560	776	-	-	-	-	-	-	-
6"	18,5	42	0,81	-	-	-	84	138	218	334	458	634	853	-	-	-	-	-	-
6"	22	48	0,84	-	-	-	71	117	185	283	389	541	730	949	-	-	-	-	-
6"	26	57	0,84	-	-	-	-	98	155	239	328	455	615	799	969	-	-	-	-
6"	30	66,5	0,83	-	-	-	-	85	135	207	284	394	531	689	834	992	-	-	-
6"	37	85,5	0,79				-	-	109	168	229	317	425	549	661	782	908	-	-
8"	22	48	0,84	-	-	-	71	117	185	283	389	541	730	949	-	-	-	-	-
8"	26	56,5	0,85	-	-	-	-	98	155	238	328	456	616	802	973	-	-	-	-
8"	30	64	0,85	-	-	-	-	87	137	210	289	402	544	708	859	-	-	-	-
8"	37	78,5	0,85	-	-	-	-	-	112	172	236	328	444	577	701	836	980	-	-
8"	45	96,5	0,82	-	-	-	-	-	94	144	197	274	368	477	577	686	800	956	-
8"	55	114	0,85	-	-	-	-	-	-	118	162	226	305	398	482	576	675	812	941
8"	63	132	0,83	-	-	-	-	-	-	-	143	198	267	347	420	500	584	699	807
8"	75	152	0,86	-	-	-	-	-	-	-	121	168	228	297	361	431	506	610	708
8"	92	186	0,86	-	-	-	-	-	-	-	-	137	186	242	295	352	414	499	579
8"	110	224	0,87	-	-	-	-	-	-	-	-	-	153	200	244	292	343	415	483
10"	75	156	0,84	-	-	-	-	-	-	-	120	166	225	292	354	422	494	593	685
10"	92	194	0,82	-	-	-	-	-	-	-	-	136	183	238	287	341	398	476	548
10"	110	228	0,84	-	-	-	-	-	-	-	-	-	154	200	242	289	338	405	469
10"	132	270	0,84	-	-	-	-	-	-	-	-	-	-	169	205	244	285	342	396
10"	147	315	0,81	-	-	-	-	-	-	-	-	-	-	-	178	211	245	293	336
10"	170	365	0,81	-	-	-	-	-	-	-	-	-	-	-	-	182	212	253	290
10"	190	425	0,79	-	-	-	-	-	-	-	-	-	-	-	-	-	183	217	248
12"	147	305	0,83	-	-	-	-	-	-	-	-	-	-	-	182	216	253	303	349
12"	170	345	0,85	-	-	-	-	-	-	-	-	-	-	-	159	190	223	268	311
12"	190	390	0,84	-	-	-	-	-	-	-	-	-	-	-	-	169	197	237	274
12"	220	445	0,85	-	-	-	-	-	-	-	-	-	-	-	-	-	173	208	241
12"	250	505	0,85	-	-	-	-	-	-	-	-	-	-	-	-	-	-	183	212
Max current for cable [A]				23	30	41	53	74	99	131	162	202	250	301	352	404	461	547	633

* At particularly favourable heat dissipation conditions.
Maximum cable length in metres from motor starter to pump.

Guide to excellence

Durability and long working life are essential for large pump sets, and obtaining excellence with submersible motors is a step towards prolonging the life of your pump set. Grundfos' R&D experience and knowhow of common pitfalls when working with submersible motors have been converted into operational knowledge-sharing in this guide to excellence.

The guide provides you with simple and easy-to-use instructions on how to avoid the most common mistakes during handling, installation and operation of your pump set. The guide covers high-risk areas only, and it is intended merely as a supplement to the Grundfos installation and operation manual.

How to use the Guide

Ensuring a long product lifetime starts with proper installation of submersible pumps. This Guide provides the installer with practical recommendations that will help avoid the most common application and installation mistakes.

The contents of this Guide are categorised according to various causes of stress, for example “Electrical stress”. This makes it easy and quick to find the relevant recommendations. This “Guide to excellence” is based on experience accumulated by Grundfos over many years, drawn from our international network of companies and service partners.

Please do not hesitate to contact your Grundfos representative if you have any comments or questions arising from this Guide.

Grundfos Product Center

At the online Grundfos Product Center, you can find all the information you need in one place.

- Retrieve relevant information such as pump sizes
- Browse the product catalogue to find specific pump information
- Find appropriate replacement pumps
- Find pumps for handling specific liquids
- Browse pump curves, technical specs, CAD drawings, available spare parts, installer guides, videos and other documentation

Visit **product-selection.grundfos.com** to see all your options.

On the product pages, you can download:

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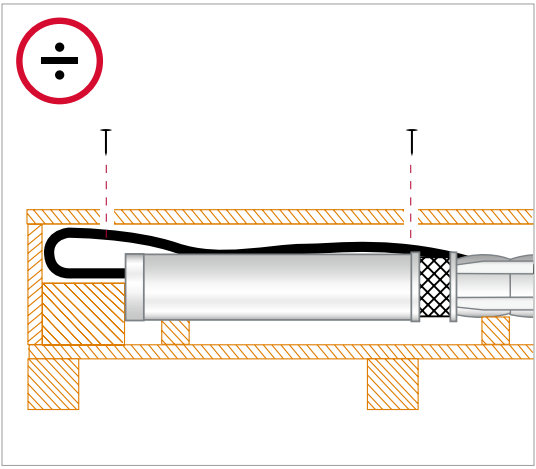
- Data booklets
- Service instructions
- Quick guides
- And much more



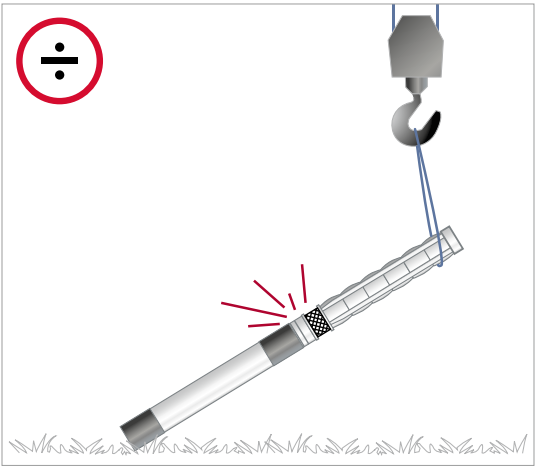
Transport to site

Pay attention to motor cables – do not cut or nail cables.

Block axial movements of motor shaft and pump set.

Support pump and motor to avoid disalignment and stress at suction interconnector (protect upper radial bearing of submersible motor).

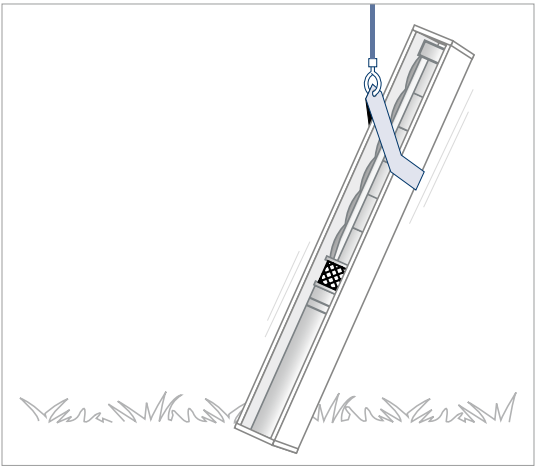
Fold cables in a large diameter – do not bend in too small radius.



Handling

Avoid shock impacts when handling pump set.

Bring packaging as close to the installation site as possible before removing pump set.

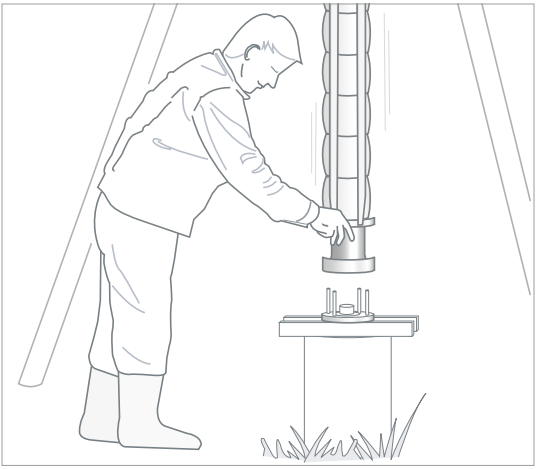


Craning/Motor liquid check

Hook up at advised points displayed on packaging.

Remove pump set from packaging in vertical position.

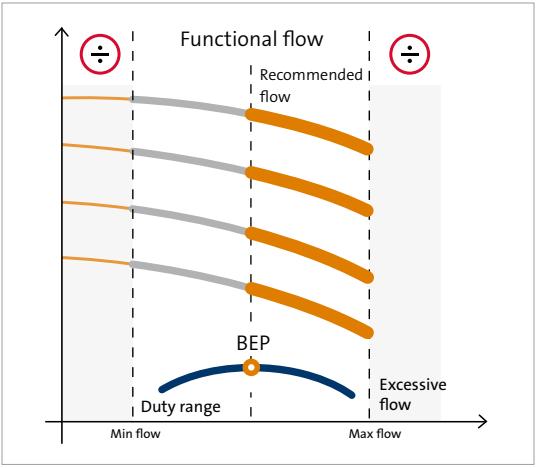
Check insulation resistance after connection of motor and drop cable.



Assembly

Assemble on site in vertical position, when pump and submersible motor are delivered in separate crates.

Do not connect discharge piping with pump set in horizontal position, as this may create disalignment when craning.

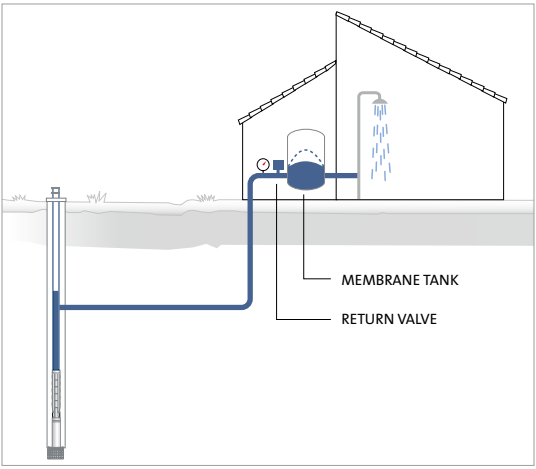


BEP (Best Efficiency Point).
The longest service intervals is offered at performances to the right hand side of BEP.

Excessive flow

Reduce flow to data booklet limitations using a throttle valve or a flow control disk.

Excessive flow creates turbulence-induced vibration in the pump unit, which is transferred to the motor shaft. Heavy motor vibration may cause wear of winding insulation or collapse of journal bearings.

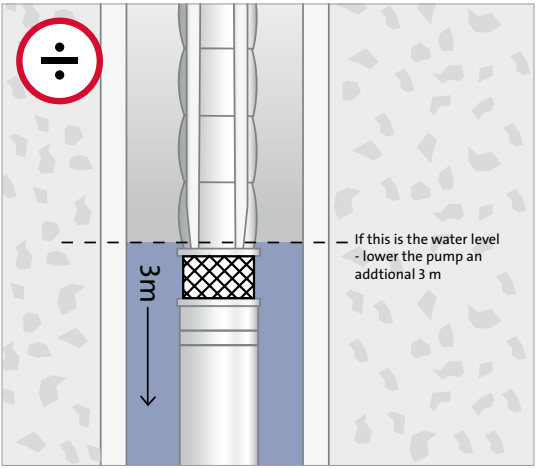


Water Hammer

When pump stops, the vertical water flow will stop flowing due to gravity.

The horizontal flow is stopped by vacuum at wellhead and swings back creating water hammer.

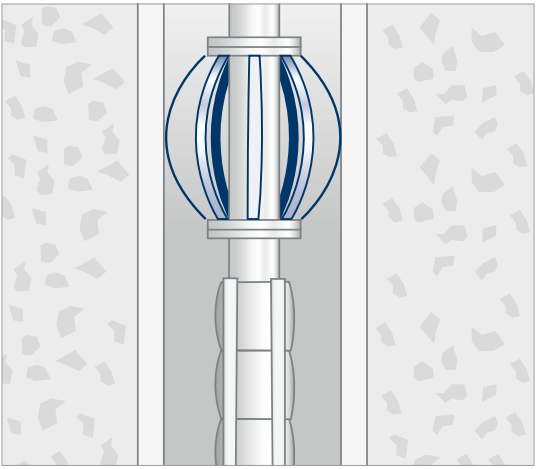
To eliminate - use membrane tank or soft start/stop.



Insufficient inlet water level (NPSH)

Lower pump setting 3-10 m or reduce flow.

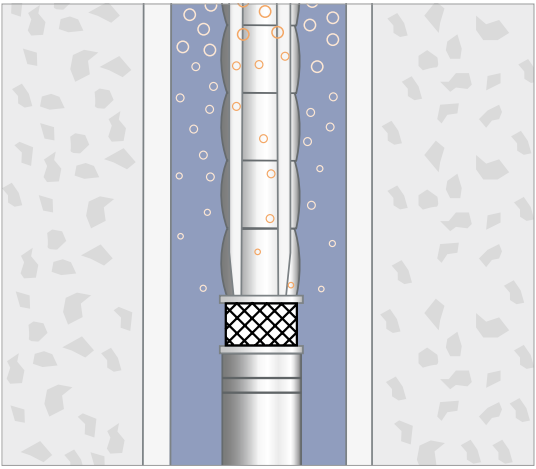
For maximum efficiency, the inlet submergence level in cold water is recommended to be at least 7 m with centric position. Lower pump in case of eccentric installation or excessive flow.



Eccentric installation in well or installation close to tank side

Install centraliser or distance positioner.

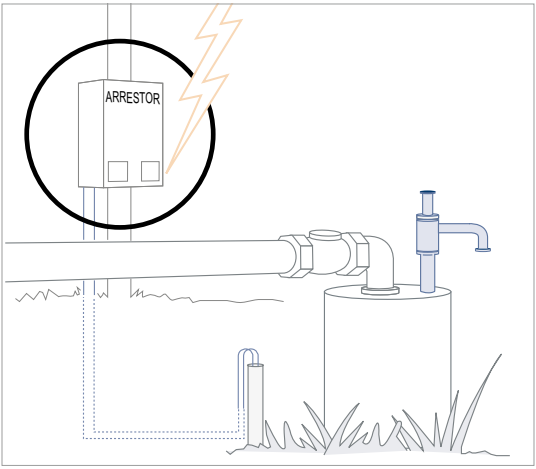
Eccentric installation may cause reduced efficiency in the first impellers due to inlet turbulence, resulting in reduced pump performance.



Gas filled water

Lower installation depth of pump and inlet.

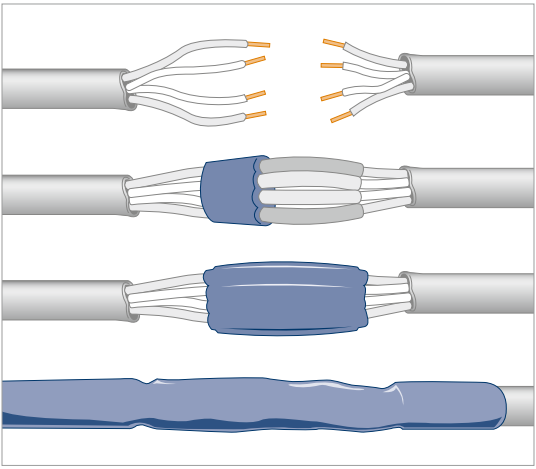
Gas/air in the water will cause reduced efficiency in the first impellers. Remove non-return valve in pump and lower the pump to at least 30 m below water level to reduce bubble size.



Lightning and transients

Install arrestor.

Transients in the power lines will reduce insulation life. Install ground wires on motor and ground at well head.



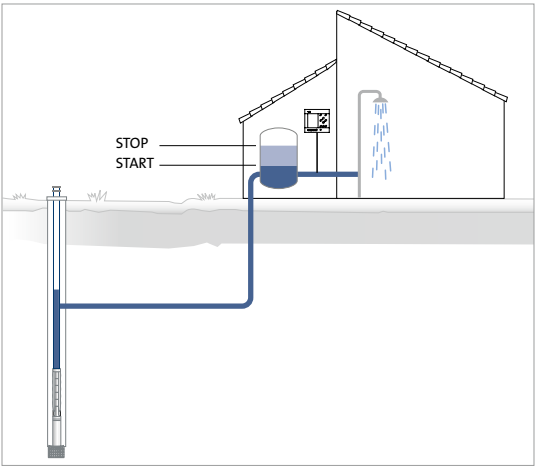
Water in cable connections

Use Grundfos-approved cables (TML) and heat shrink termination.

PVC winding and H07RNF motor cables are acceptable for cold water (10° C) and shallow settings. For deep settings, use PE/PA winding and TML B motor cable.

Check insulation resistance after connection of motor and drop cable.

If the insulation resistance is less than 0.5 MΩ the motor should be pulled out for motor or cable repair.



Frequent starts and stops

Keep start/stop frequency at a minimum to prolong the lifetime of the pump set. The motor wil consume 6 x normal power at start-up, causing overheating of windings. Frequent start/stop will affect winding insulation.

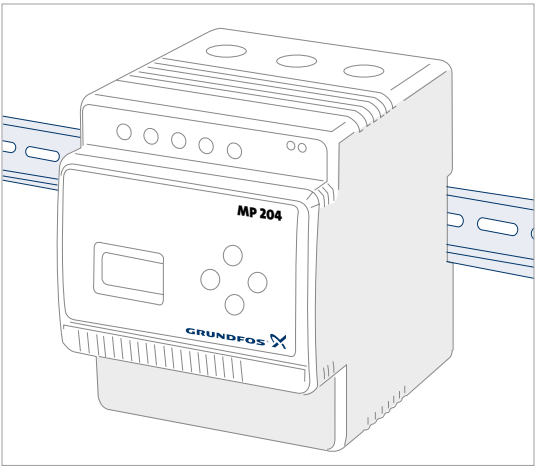
Protection against frequent start and stops
When pressure tanks controls the storage volumen between start and stop, make sure that:

1. You have the right tank size:

$$V = \frac{Q \times 1000\ (1 + \text{cut - in}) + \Delta p}{4 \times n_{max} \times \Delta p} \times \frac{1}{k}$$

V	= Tank volume [litres]
Q	= Mean flow [m³/h]
Δp	= Difference between cut-in and cut-out pressure
Cut-in	= Cut-in pressure (lowest) [bar]
n_{max}	= Max. number of starts/stops per hour
k	= Constant for diaphragm tank pre-charge pressure: k = 0.9

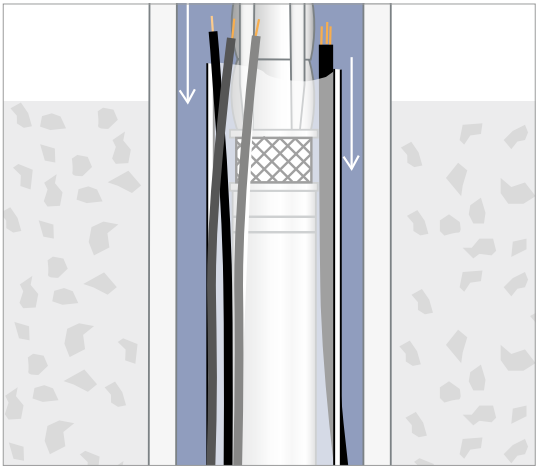
2. You test precharge pressure (air volumen) twice a year. If you experience frequent start/stop, install MP204 controller for motor temperature protection.



Power failures

Install proper motor protection.

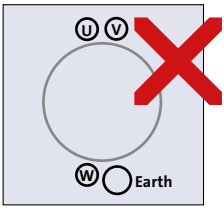
Voltage imbalance will create hotspots in motor windings and lead to increased motor liquid temperature. Rotate the three wires at terminal to minimise unbalance and install motor protection MP 204.

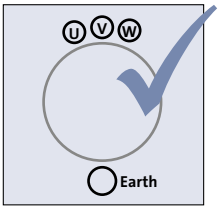


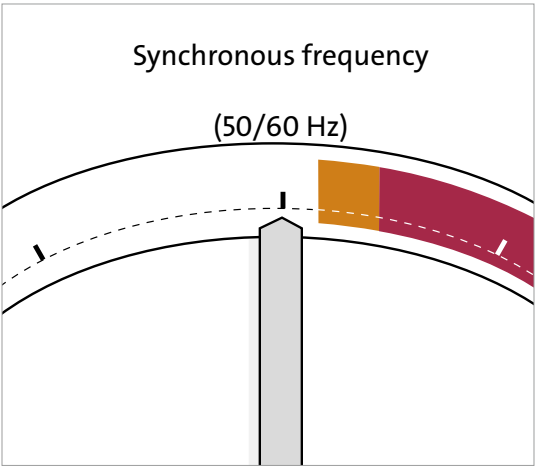
Cabling current asymmetry

Generator Earthing - It is important that the aquifer where the pumpset is installed is used as reference earth potential for the generator.

Two possible causes:
Voltage asymmetry results in current assymetry. Arrangement of (long) drop cables on the riser can increase current assymetri. Recommendation is to arrange earth cable on the riser opposite the three phase leads.





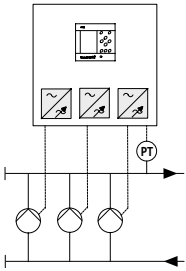


Generator power

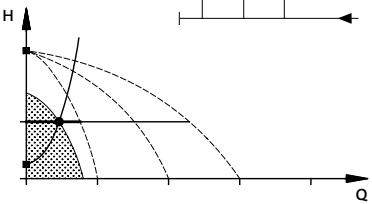
Avoid oversynchronous frequencies and coasting down of generators at pump stop.

Periodic oversynchronous frequencies will cause overloading/overheating of the motor. Remove impellers or oversize motor in case of oversynchronous frequencies.

Hydro MPC-EF
Hydro MPC booster set with three SP pumps connected to external frequency converters in the control cabinet.

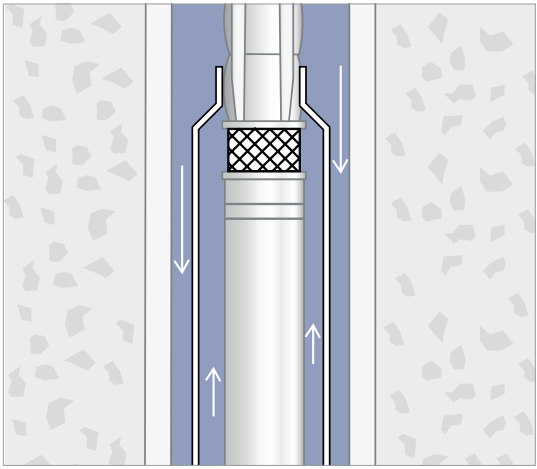


On SP pump connected to an external frequency converter in operation



CUE

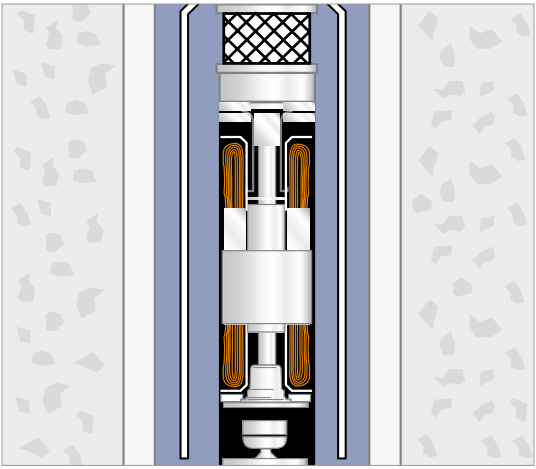
- Parrallel operation of more wells.
- External frequency converters type CUE.
- Hydro MPC-EF maintains a constant pressure through continuously variable adjustment of the speed of the pumps.
- The performance is adjusted to the demand through cutting in/out the required number of pumps and through parallel control of the pumps in operation.
- Pump changeover is automatic and depends on load, operating hours and fault.
- All pumps in operation will run at equal speed.



Feeding from above the pump

Install flow sleeve.

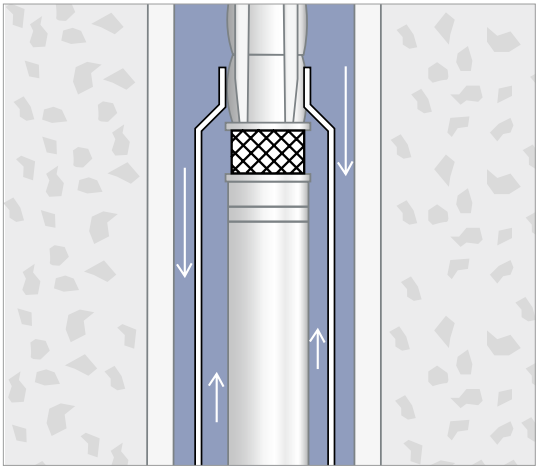
Feeding from above will cause overheating of the motor surface. The overheated motor surface will scale up with organic and inorganic (lime) deposits, reducing the lifetime of the motor.



Water temperature above 15° C

In case of rewindable motors, use PE/PA windings. Two-layer PE/PA winding increases the lifetime of the motor.

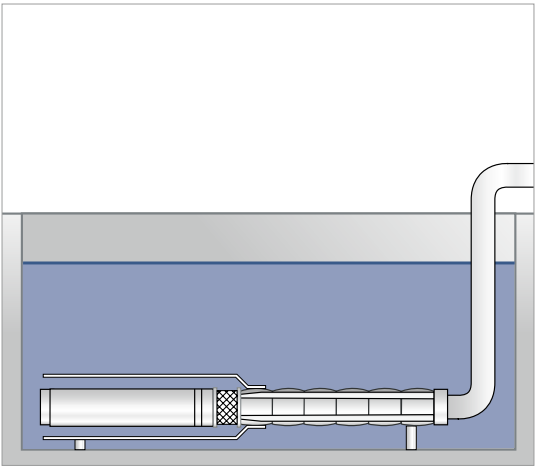
For temperatures from 40-60° C use canned type or special hot water motors.



Silting up around motor

Install flow sleeve.

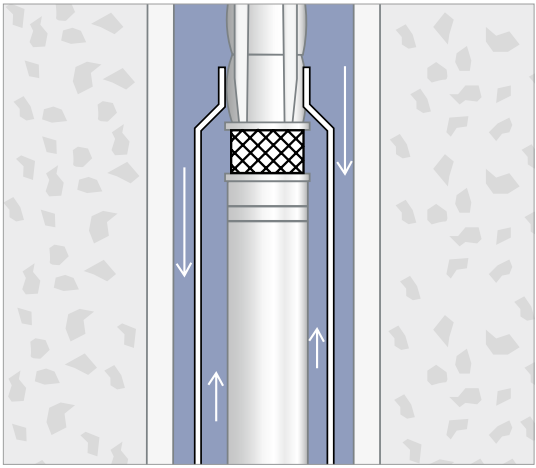
Deposition of solids and silt around motor and shaft will cause wear of shaft seal. Installation of a flow sleeve ensures flow rates higher than 0.5 m/s, preventing deposition of solids and silt around motor and shaft.



Horizontal and/or tank installation

Install flow sleeve.

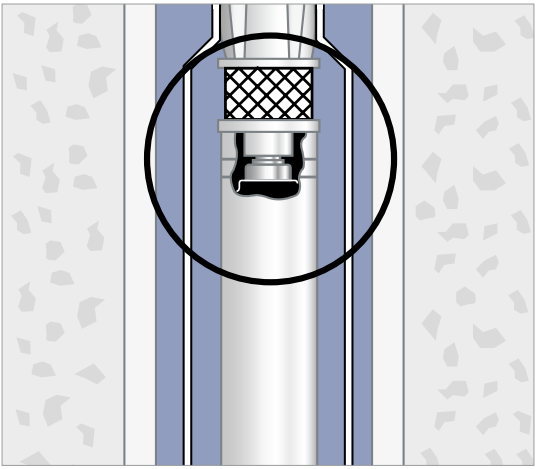
Installation of a flow sleeve will prevent scaling on motor surface and give better cooling, cf. page 19.



Insufficient frequency

Install flow sleeve and never regulate below 30 Hz, or minimum flow requirement.

A cooling sleeve is a prerequisite for obtaining 0.15 m/s cooling flow at low frequencies.



Sand particles

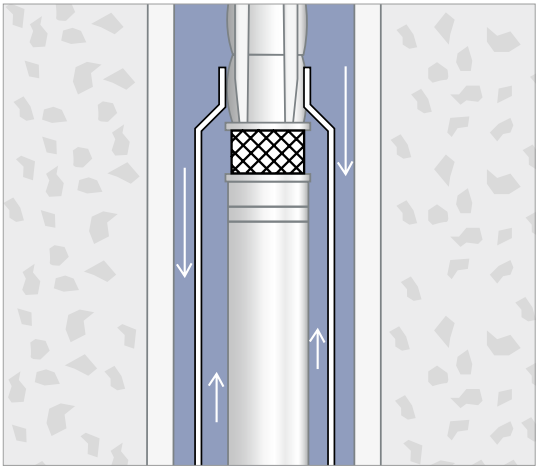
Use Sic/Sic shaft seal and flow sleeve.

Replacing standard shaft seal with silicon carbide seal (Sic/Sic) will minimise the amount of abrasive sand entering the motor interior.

Iron bacteria

Disinfect well.

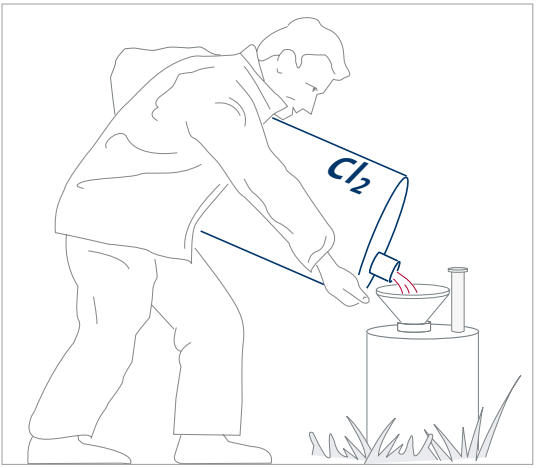
Iron bacteria can be killed with acid and disinfection agents.



Iron and manganese

Install flow sleeve.

Reduce surface temperature with flow sleeve in case of scale deposits on motor surface.



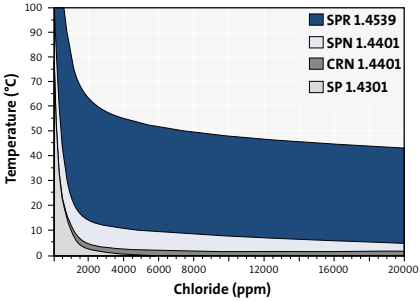
Marine life

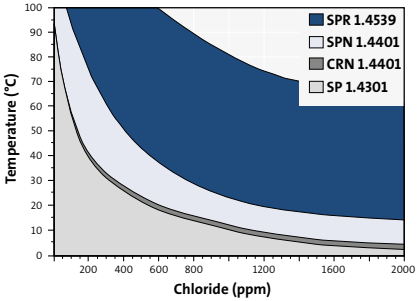
Disinfect intake structure.

Marine life blocking the pump inlet can be killed with chlorine or other disinfection agent.

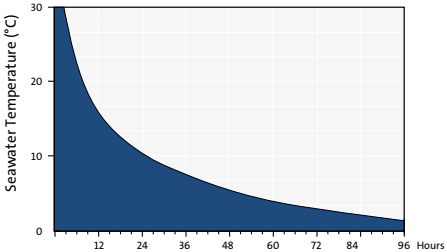
Materials for aggressive water

Corrosion diagram
W.nr. 1.4301, 1.4401 and 1.4539

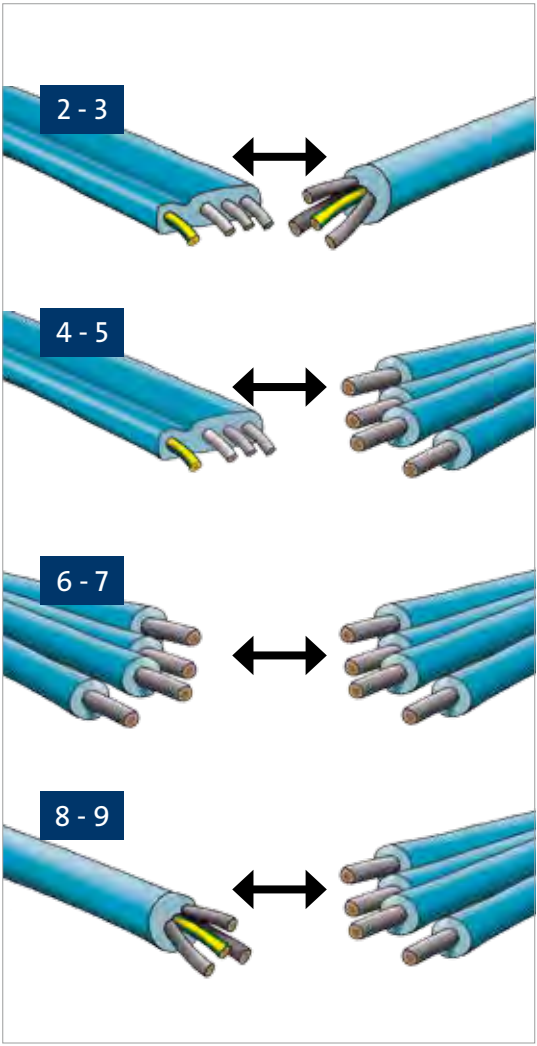


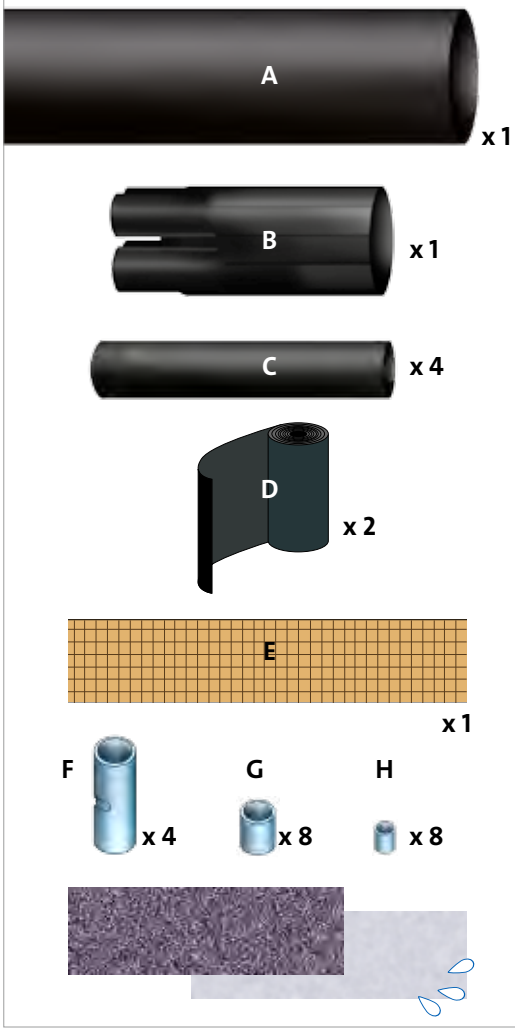


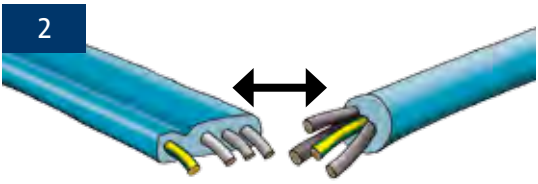
Recommended maximal deactivation in seawater when without zinkanodes

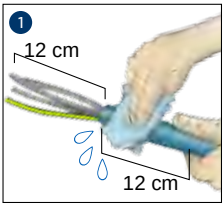


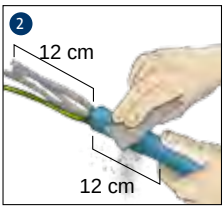
Joining motor and drop cable (KM type)

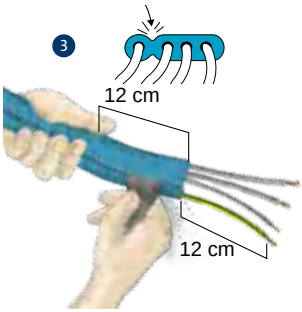


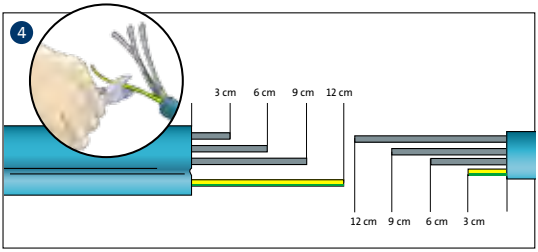

A
x 1
B
x 1
C
x 4
D
x 2
E
x 1
F
x 4
G
x 8
H
x 8

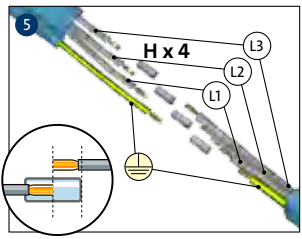

2

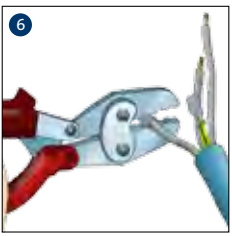

1
12 cm
12 cm


2
12 cm
12 cm

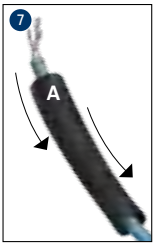

3
12 cm
12 cm

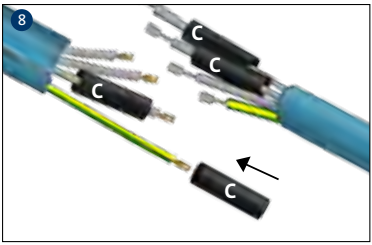

4
3 cm
6 cm
9 cm
12 cm
12 cm
9 cm
6 cm
3 cm

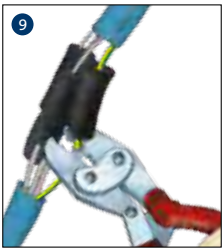

5
H x 4
L3
L2
L1

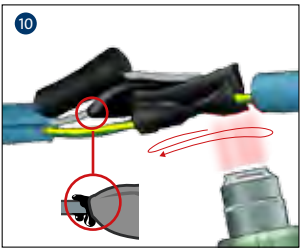

6

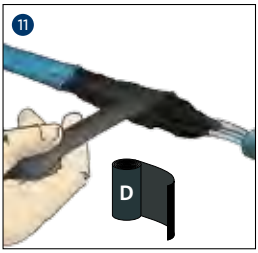
3

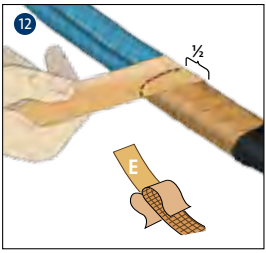


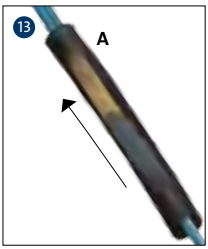


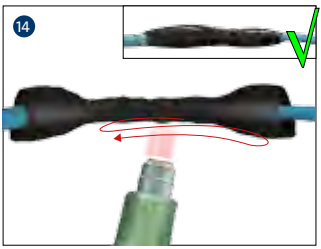


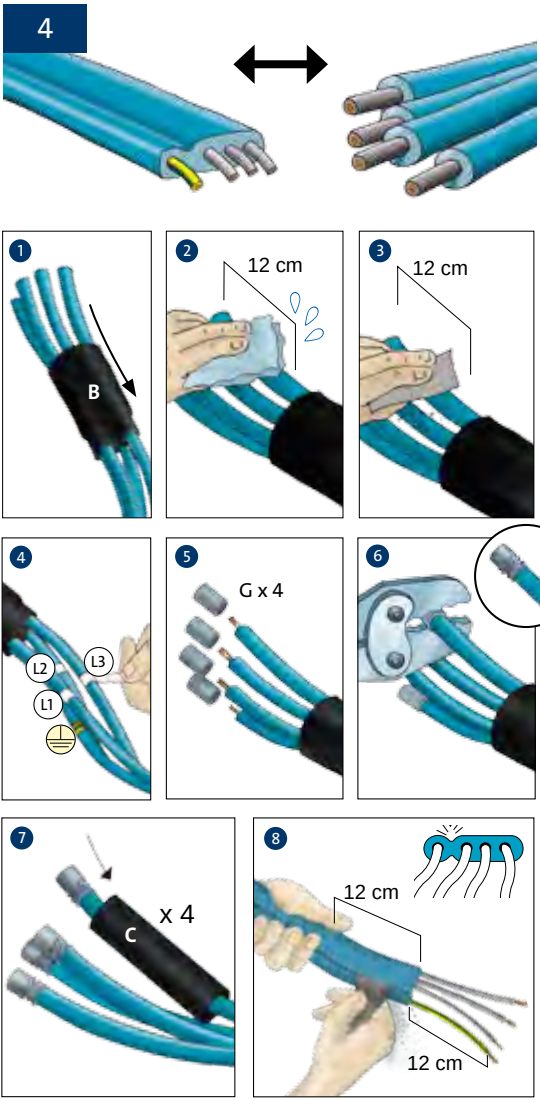




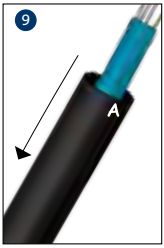


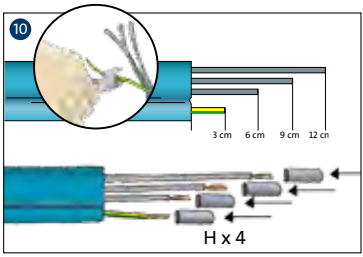


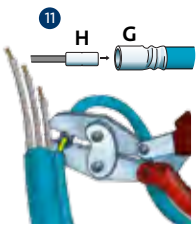


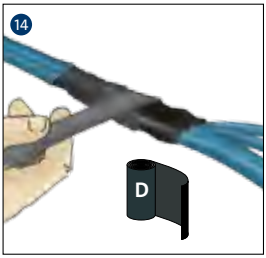

4
1
B
2
12 cm
3
12 cm
4
L2
L3
L1
5
G x 4
6
7
x 4
C
8
12 cm
12 cm

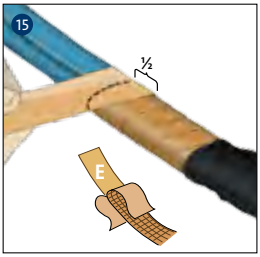
5

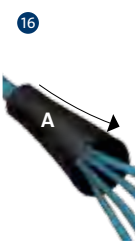


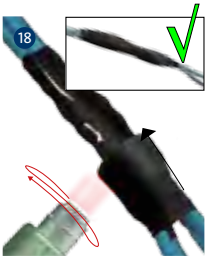


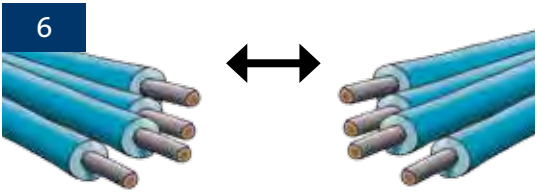


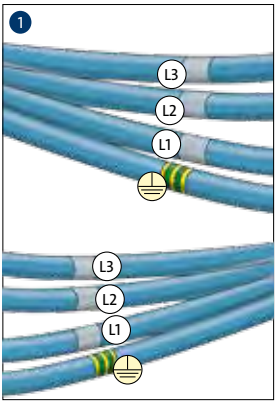


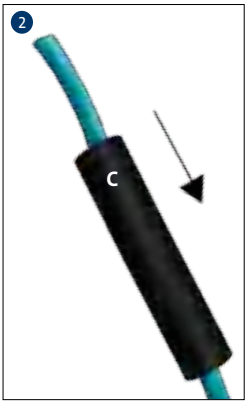







6

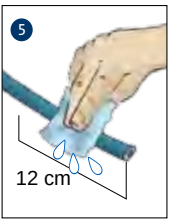

1
L3
L2
L1
L3
L2
L1

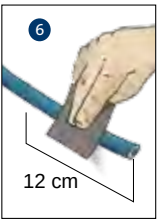

2
C


3
12 cm

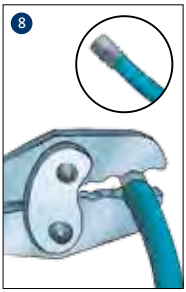

4
12 cm

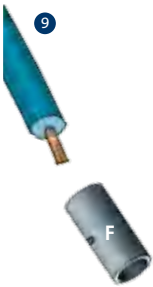

7

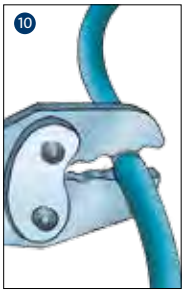

5
12 cm

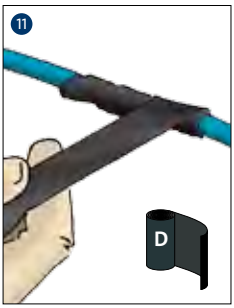

6
12 cm

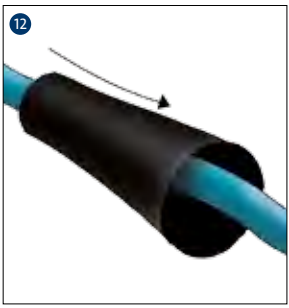
7

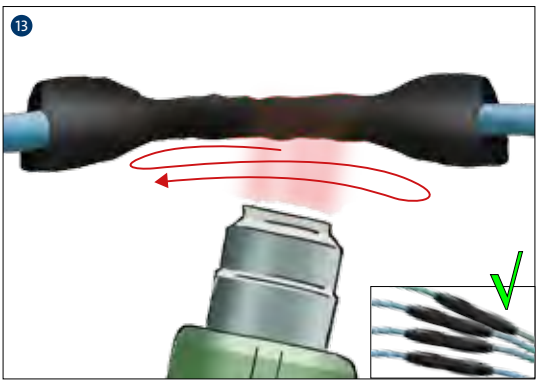


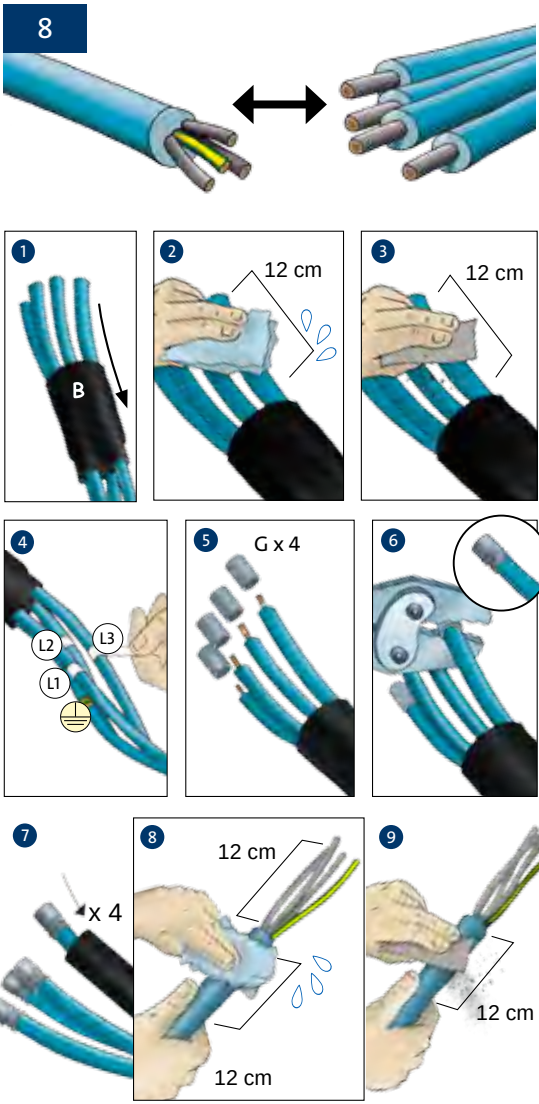




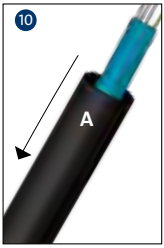


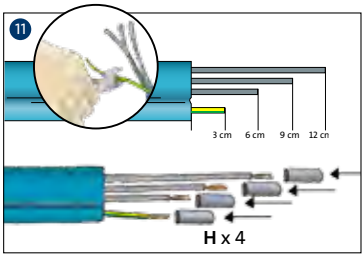


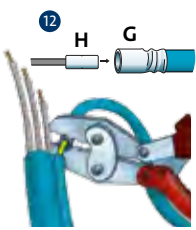


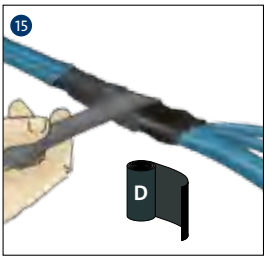

8
1
B
2
12 cm
3
12 cm
4
L2
L3
L1
5
G x 4
6
7
x 4
8
12 cm
12 cm
9
12 cm

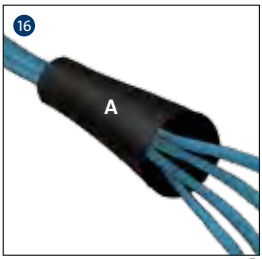
9

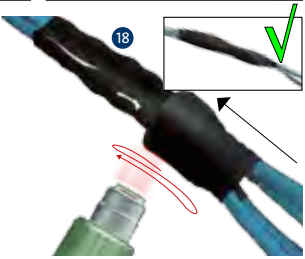












Cable dimensions for submersible motors at 3 x 400 V, 50 Hz, Direct On Line.
Voltage drop 3%

Motor	kW	[A]	Cos 100%	1,5	2,5	4	6	10	16
4"	0,37	1,4	0,64	462	767	-	-	-	-
4"	0,55	2,2	0,64	294	488	777	-	-	-
4"	0,75	2,3	0,72	250	416	662	987	-	-
4"	1,1	3,4	0,72	169	281	448	668	-	-
4"	1,5	4,2	0,75	132	219	348	520	857	-
4"	2,2	5,5	0,82	92	153	244	364	602	951
4"	3	7,85	0,77	69	114	182	271	447	705
4"	4	9,6	0,8	54	90	143	214	353	557
4"	5,5	13	0,81	39	66	104	156	258	407
4"	7,5	18,8	0,78	28	47	75	112	185	291
6"	4	9,2	0,82	55	91	146	218	359	566
6"	5,5	13,6	0,77	40	66	105	157	258	407
6"	7,5	17,6	0,80	29	49	78	117	193	304
6"	9,2	21,8	0,81	23	39	62	93	154	243
6"	11	24,8	0,83	-	34	53	80	132	209
6"	13	30	0,81	-	28	45	68	112	176
6"	15	34	0,82	-	-	39	59	97	154
6"	18,5	42	0,81	-	-	-	48	80	126
6"	22	48	0,84	-	-	-	41	67	107
6"	26	57	0,84	-	-	-	-	57	90
6"	30	66,5	0,83	-	-	-	-	49	78
6”	37	85,5	0,79				-	-	63
8"	22	48	0,84	-	-	-	41	67	107
8"	26	56,5	0,85	-	-	-	-	57	90
8"	30	64	0,85	-	-	-	-	50	79
8"	37	78,5	0,85	-	-	-	-	-	65
8"	45	96,5	0,82	-	-	-	-	-	54
8"	55	114	0,85	-	-	-	-	-	-
8"	63	132	0,83	-	-	-	-	-	-
8"	75	152	0,86	-	-	-	-	-	-
8"	92	186	0,86	-	-	-	-	-	-
8"	110	224	0,87	-	-	-	-	-	-
10"	75	156	0,84	-	-	-	-	-	-
10"	92	194	0,82	-	-	-	-	-	-
10"	110	228	0,84	-	-	-	-	-	-
10"	132	270	0,84	-	-	-	-	-	-
10"	147	315	0,81	-	-	-	-	-	-
10"	170	365	0,81	-	-	-	-	-	-
10"	190	425	0,79	-	-	-	-	-	-
12"	147	305	0,83	-	-	-	-	-	-
12"	170	345	0,85	-	-	-	-	-	-
12"	190	390	0,84	-	-	-	-	-	-
12"	220	445	0,85	-	-	-	-	-	-
12"	250	505	0,85	-	-	-	-	-	-
Max current for cable [A]				23	30	41	53	74	99

* At particularly favourable heat dissipation conditions.
Maximum cable length in metres from motor starter to pump.