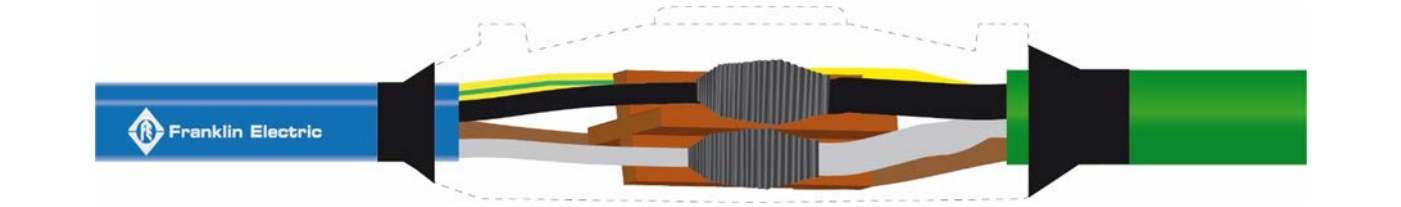
After having explained why submersible pump cables are different, let us have a look at how to correctly size a so-called “drop cable”.



In most cases, submersible motors will come supplied with a short electrical cable. For space constraints (it must be routed alongside the submersible pump in the narrow borehole space), it is usually selected by the manufacturer such that:

- It is a reduced cross section cable – just enough to carry the motor full load current in cold water (30°C)
- It is usually of the individual or flat jacketed construction
- It may require a separate earth cable to save space and add flexibility
- The outer sheath is usually selected in compliance with specified drinking water regulations

If you simply took the same cable type to cover the distance to the above ground electrical panel, the cable would most likely burn and so would your submersible motor. This is because

- the cable will overheat when it gets out of the cold well water and into hot air
- of its length, it will generate a large voltage drop so the motor will be under-supplied

For these reasons, borehole professionals will splice the motor short lead to a larger cross-size “drop cable” that will safely carry the required current and supply the motor with the desired voltage. So how to select the right cable type?

General Selection Algorithm

Input (data you need for sizing the cable):

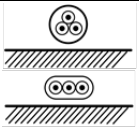
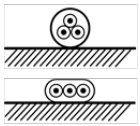
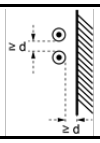
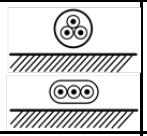
- Chemical properties of the water
- Temperature of well water
- Temperature of air (in the well and along the entire cable run)
- Max. submergence (or max. pressure in booster applications)
- Agency requirements:
  - Related to hygienic/sanitary aspects (drinking water approved materials)
  - Related to local or industry electrical/mechanical codes (heavy duty cable construction, EMC compatibility etc.)
- Nominal operating voltage of load (when used with a VFD, make sure the cable insulation materials are suited for typical stresses of VFD operation)
- Nominal motor current
- Cos fi (power factor) of motor
- Total length (from submersible motor to pump panel)

Franklin Electric Europa GmbH Tel.: +49 (0)6571 105 - 0
Rudolf Diesel Straße 20 Fax: +49-(0)6571 105 - 511
D-54516 Wittlich/Germany
field-service@franklin-electric.de
www.franklin-electric.eu

CALCULATION

1. Select cable mechanical construction according to chemical properties and agency approvals. Most cable manufacturers will have several cable types in their catalogues to choose from.

2. Choose correct sizing (cross-section)
   - Determine the **minimum** cross section of the cable capable of carrying the motor current under the specified environmental conditions: temperature of water/air and method of installation. Most cable manufacturers will tabulate the data as in the example below:

No. of loaded conductors	Max. conductor temperature 90 °C				Max. short circuit temperature 200 °C	Max. short circuit temperature 250 °C
	3	3	1	3	-	-
	In air	In air contacted by walls and floors	In water	In water	Tinned conductor	Plain Conductor
Nominal Cross Section					-	-
mm²	Current ratings in ampere for an ambient temperature of 30 °C				Max. short circuit current (1s)- kA	
1	19	18	-	23	0,12	0,14
1,5	24	23	42	29	0,18	0,21
2,5	32	30	54	38	0,31	0,36
4	43	41	74	52	0,49	0,57
6	56	53	96	67	0,73	0,86
10	78	74	133	94	1,22	1,43
16	104	99	179	125	1,95	2,29
25	138	131	236	166	3,05	3,58
35	171	162	293	205	4,27	5,01
50	213	202	365	256	6,1	7,15
70	263	250	451	316	8,54	10
95	317	301	544	380	11,6	13,6
120	370	352	635	444	14,6	17,2
150	425	404	730	510	18,3	21,5
185	485	461	832	582	22,6	26,5
240	576	547	988	691	29,3	34,3
300	666	633	1142	799	36,6	42,9

***) The current ratings for use in water are valid for the installation in water with the total length. The calculated value is 20 % higher than the value of the installation in air.**

Correction factor for ambient air temperature other than 30 °C															
Ambient temp. °C	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
Conversion factor	1,18	1,14	1,10	1,05	1	0,95	0,89	0,84	0,77	0,71	0,63	0,55	0,45	0,41	0,29

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Fax: +49-(0)6571 105 - 511

This is the most economic cable size that can carry the current of your pump under the specified environmental conditions. HOWEVER, due to the inherent voltage drop along the cable, you must check for the maximum allowable cable length in a second calculation.

1. Calculate the maximum allowable cable length
   - Set the maximum allowable voltage drop your application will allow (usually between 3% and 5%)
   - Take the determined minimum cross-section determined under point 2. and use a voltage drop calculation formula (example given below for a 3 phase motor) to determine the maximum permissible lead length for the given cross-section:

   L = dv / (sqrt((v* cos(φ) + a*r)^2 + (v*sin(φ) +a*x)^2) -v)
   where:
   r = specific resistance, [Ω /m]
   x = specific reactance, [Ω /m]
   a = rated current of motor, [A]
   cos(φ) = power factor of motor, [-]
   v = rated voltage of motor, [V]
   dv = allowable voltage drop, example: 0.05* v for a 5% voltage drop
   L = maximum allowable cable length for specified voltage drop

   Values for r & x must be specified by the cable manufacturer.

If the result of the calculation is matching or exceeding the required length for your application, this is the cable type you want to use. However, in most cases, the smallest cross-section (the most economical lead) will not be suitable for the length needed, so the calculus must be redone with the next higher available cross-section (check the manufacturer tables for available cross-sections). Redo the math in an iterative way until the result matches or exceeds the required total length of your application.
As the above is time-consuming and requires access to cable manufacturer data, most submersible pump manufacturers provide tabulated data for drop cable leads in function of the rated motor/pump power and voltage.
However, depending on the assumptions made, the type of cables chosen and safety factors applied, you will notice different recommended cable sizes for the same pump/motor rating coming from different manufacturers. Also, these tables are usually only available for standard supply voltages, ambient temperatures and cable construction materials.
With Franklin Electric submersible motors, these tables come with the motor manuals or can be conveniently downloaded from the internet.
In the next AID Bulletin, we will take you through a practical example of drop cable selection for a submersible pump application.

SAVE THE DATES

Keep yourself and your colleagues up-to-date with the latest developments in submersible borehole technology and trends. We're offering conveniently-timed, off season technical seminars for industry professionals at our Wittlich, Germany training facility.
For information on scheduled seminars please send us an email to field-service@franklin-electric.de.

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