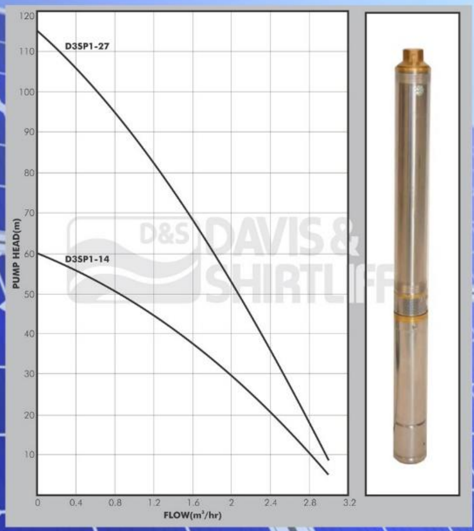
SMART Centres



Electrical pumps selection & installation

Simple,
Market based,
Affordable,
Repairable
Technologies

www.smartcentregroup.com

The **SMART** Centre Group

Contents

1 Introduction

This document describes the selection and practical issues to consider with electrical submersible pumps. The selection procedure (Chapter 2) is applicable for all types of pump. Other chapters focus more on smaller pumps for example suitable for one household is small garden and few livestock. If you are interested in bigger systems, we recommend studying: https://globalwatercenter.org/solar-guide-access.

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2 Pump selection

The best fitting type of pump depends on:

1. Required flow = how much water does the customer need per time frame.

2. Required pressure = How high must the pump be able to deliver water.

2.1 Required flow

Required flow also sometimes called "Yield" is often mentioned in Litres per minute or Litres/hour (1 L/h=1/60=0.017 L/min) or cubic meter per hour (1m³/h=1000/60=17L/min) or cubic meter per day (1m³/day=1000/24/60=0.7L/min) In this manual we will use L/min.

To define the required flow (=yield) of a pump the following things are essential

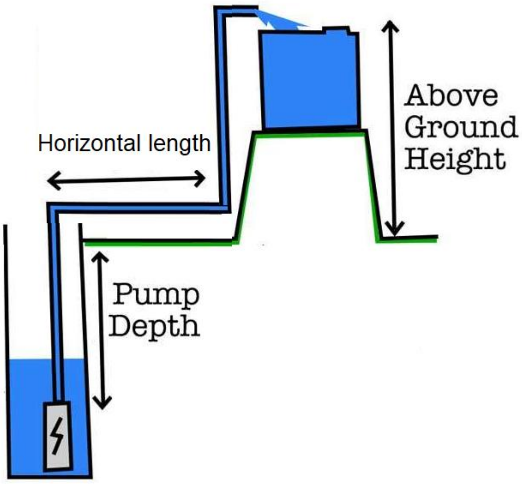
- How many litres of water does the customer need per day divided by the number of minutes that the pump will be functioning in a day.
- Now you have to check if the borehole or well is able to provide that amount of water per minute. This information comes from the pump test.
    - If the pump test shows that the borehole or well cannot deliver the required yield then you need to inform your customer. Because no pump can pump water that is not there. A slow well can be caused by many thinks but nature plays an important roll. Some soils simply don't allow water to pass quickly.
      In this case choose a pump yield equal to the borehole or well yield.
    - If the borehole or well delivers water faster than the flow required by the customer then use that customer required flow to select your pump.

Example:

The household only uses water for the house and needs 1000 litre per day. The customer wants a solar powered pump. There are 5 hours of enough sun every day. Then the minimum yield of the pumps should be 1000/5=200 Litre/hour = 200/60 =**3.3 L/min**.

2.2 Required pressure

There required pressure also sometimes called "Head" is often mentioned in meter water column or in bar (1 bar = 10 m water column) or in Pascal (1 kPa = 0.1 m water column). In this manual we use meter water column.



To find the required pressure that a pump has to provide, you need to add up all vertical lengths of the outlet pipe plus a part of all horizontal pipe lengths. The last is to compensate for horizontal pressure loss due to friction in the pipe. This gives you the required pump head in meters water column.

Pump head = Pump depth + Above ground height + Horizontal length / X(*)

Enter all dimensions in meters and the result will be in meter water column.

(*) Horizontal pressure loss "X" is difficult to calculate and depends on: flow, pipe diameter, horizontal length and number of bents.

See http://www.pressure-drop.com/Online-Calculator/ or https://www.copely.com/tools/flow-rate-calculator

Rule of thumb to make it easy:

- At flow of 20 Litre/min or less and 20mm pipe diameter use: Horizontal length **/ 12**
- At flow between 20 L/min and 50 L/min and 25mm pipe diameter use: Horizontal length **/ 6**
- At flow between 50 L/min and 100 L/min and 32mm pipe diameter use: Horizontal length **/ 6**

Example

For example: pump is at 5m deep, top of tank is at 4.5m and the horizontal distance between borehole and tank is 6m. The flow is less than 20 L/min, pipe diameter= 20mm .

Pump head = Pump depth + Above ground height + Horizontal length / X

= 5m + 4.5m + 6m/12

= **10 m** water column

How deep must the pump be installed?

Read appendix "Appendix:

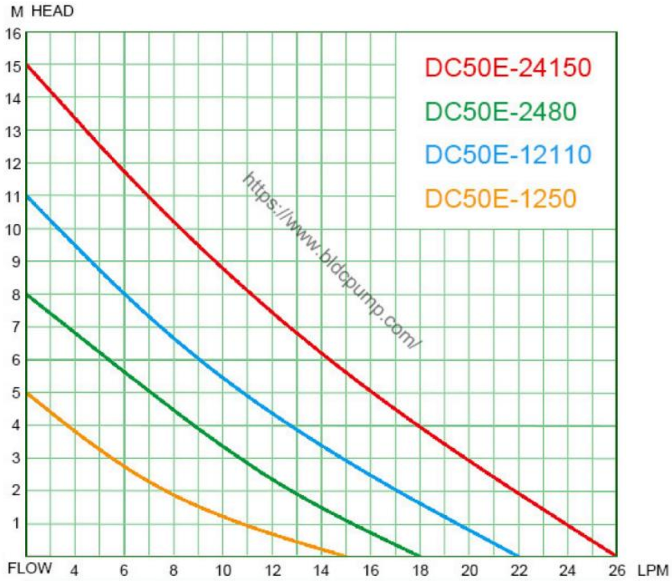
Where to install a submersible pump in a borehole" to find out where how deep to install the pump.

2.3 Pump diagram

Each pump has its own characteristics. It will pump a lot of water with a low pressure and it will pump less water if it has to pump up high. These characteristics are presented in a pump diagram. Each type of pump has its own line in a diagram.

In the example are 4 types of pumps.

- The vertical axe gives the pressure (head) in meters water column.
- The horizontal axe gives is the flow (how mu ch water) that the pump will produce at a specific pressure in LPM = Litres Per Minute.



Exercise

Please try to find out how much water (flow) the DC50E-12110 pump will deliver if it has to pump water up to 6 meters.

Example

Let's use the same customer as in the examples above. They needed a pressure of 10 metres and a flow of= 3.3 Litres/minute or more

A. Draw a horizontal line at 10 m head to the right
B. Draw a vertical line at 3.3 Litres/minute up

All pumps with lines above line A (more than 10m head) and to the right of line B (more than 3.3 Litres/minute) are pumps that qualify for this customer.

So in this example pump DC50E-12110 (blue line is just enough because its curve just crosses the pressure and flow demand (left bottom of the square)

Pump DC50E-24150 (red line) can easily deliver what is needed for this example customer.

2.4 Don not buy a pump before the well is ready

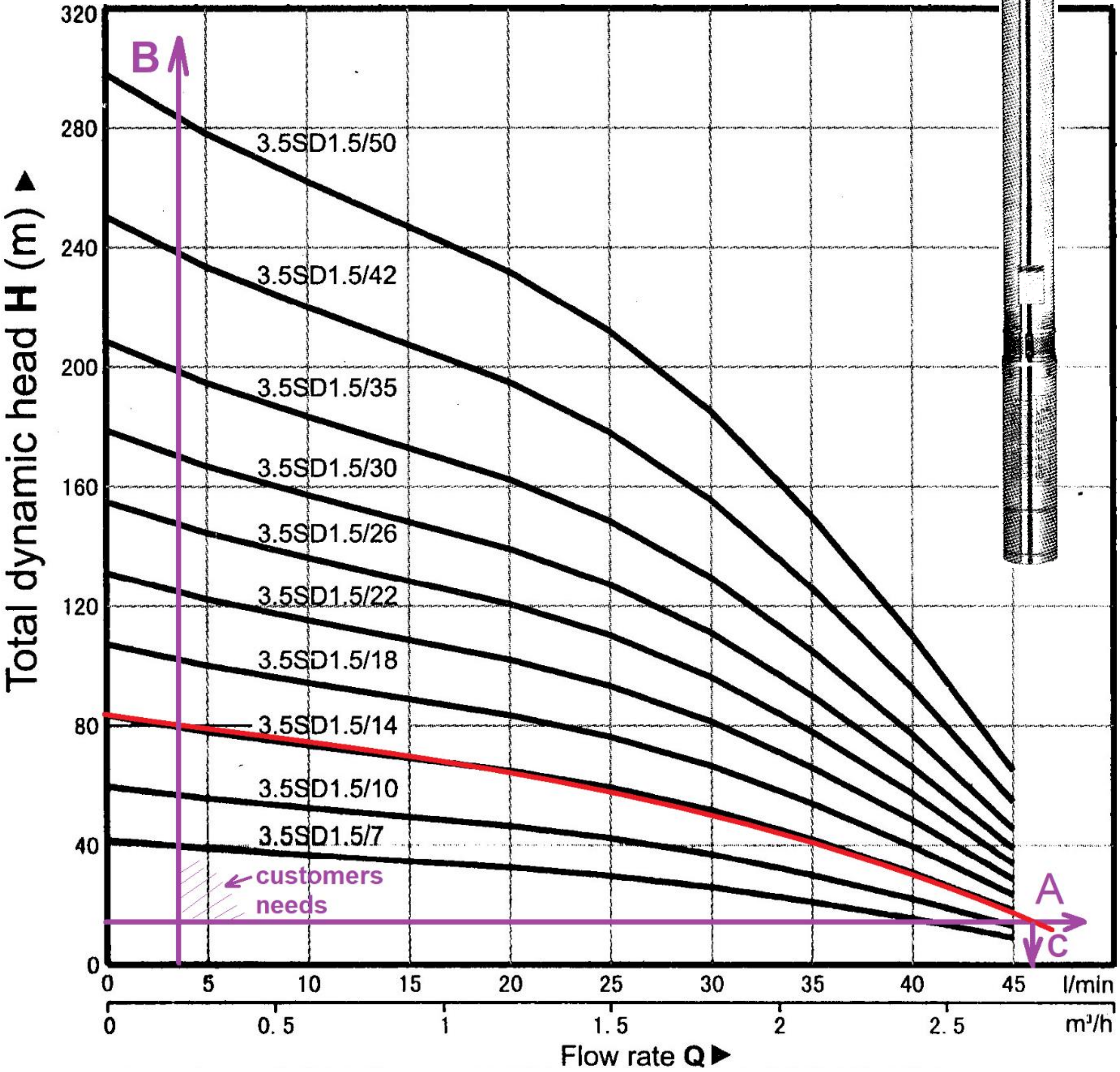
Customers should never buy a pump before the well is ready and tested so you know the yield of the borehole. If a borehole is in a “slow aquifer” for instance in loam or clay, then the flow of water into the well will be very slow and a too big pump will run dry quickly.

Often people buy a pump that is much too big for the amount of water they need.

Example

For example; the same customer as before bought the pump model 3.5SD1.5/14

If you draw line A at pressure 10m horizontal to the right it will cross the pump line after 45 litres/minute (see line C). While the customer needs only 3.3 L/min.



Meaning this pump (and possibly solar panels) will work only 1000/45= 22 minutes every day and then its job is finished for that day. This system is not only much too big and too expensive for the job, it also puts unnecessary stress on the borehole, casing and gravel pack. It might even suck in sand or clog the filter screen one day. In this case a small pump will serve the customers needs just as well and even better because it will not suck sand or put stress on the borehole.

2.5 Combining two or more pumps

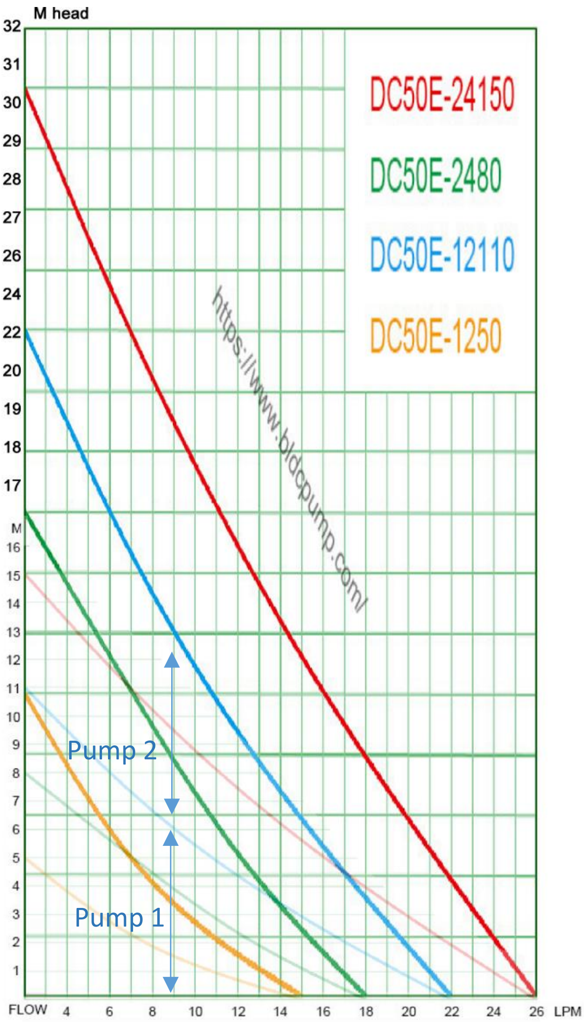
Unfortunate not all types of pumps are available in the shops. You need to work with what you can find. But you can be creative and combine two or even more pumps to serve your customer:

It is possible to combine pumps in series or parallel.

Connecting pumps in series

If you connect two of the same pumps in series you will double the **pressure** with the at the same flow:

This example shows small pumps, but you can do this for bigger types as well.



Exercises

Instead of 10m the customer now has to pump up to 20m. How many L/min flow do two DC50E-12110 pumps in series provided?

Connecting 3 pumps in series would theoretically triple the pressure etc.

Connecting pumps in parallel

If you connect two pumps parallel it will double the **flow** at the same pressure:

3 Pump protection

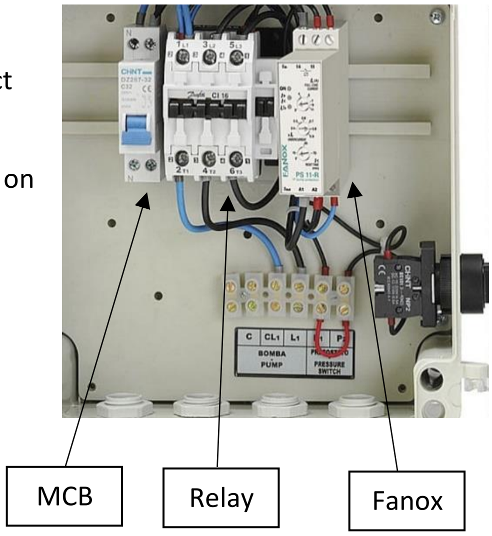
1. When a pump is running without water it will be damaged very quickly. So we have to make sure the pump is switched off when the borehole or well cannot deliver sufficient water.
2. Pumps also do not like to run without water passing through because they will heat up. For example when the in- or outlet pipe is blocked.
3. Pumps also do not like sand or other particles. Sand will wear out the pump fast or it can even jam the pump completely. In this case the pump must switch of.
4. Some pumps do not like a voltage that is too low or too high. (Some pumps like the BLDC and the ZLDC pump have a low and high voltage protection build in.)

3.1 Protecting 240 Volt AC pumps standard type

Some expensive submersible pumps (like some Grundfoss pumps) have all these protections build inside the pump, ask the supplier. Otherwise you will have to add some kind of control box to protect the pump.

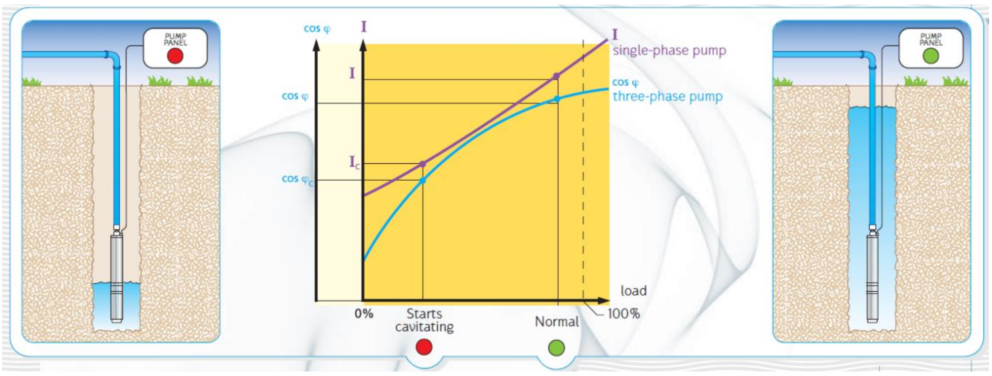
Fanox sensors can be used for bigger submersible pumps that run on 240 Volt AC:

With water sensors in the borehole or with Fanox:



- Fanox switches power off in case of overload, high voltage or dry borehole. After some minutes, it will switch on again.
- Fanox is sensitive and not build for heavy load. That is why it gives this signal to a Relay which is switching the pump on and off.
- The MCB is there to protect all for short circuit.

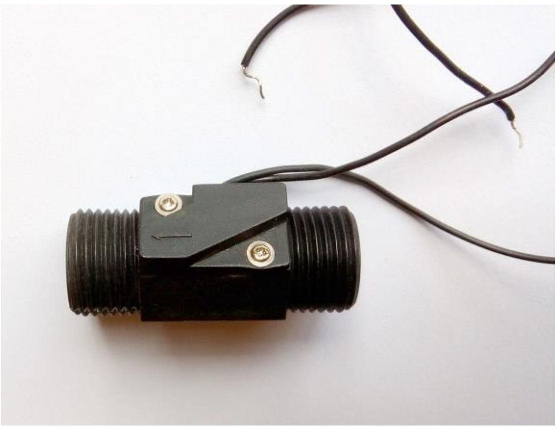
Costs: A Fanox sensor can cost as much as a ½ horse power submersible pump.



3.2 Cost efficient pump protection.

If water is running through the pump then we know there is water in the well. A simple flow switch placed somewhere in the pump outlet pipe will detect if water is still running. Once water stops flowing, this sensor switches off the pump. When the problem is solved the pump can be restarted.

Just like the expensive Fanox (mentioned above) also a flow switch cannot handle the required amps running the pump and therefore also requires a relay to switch the pump on and off.



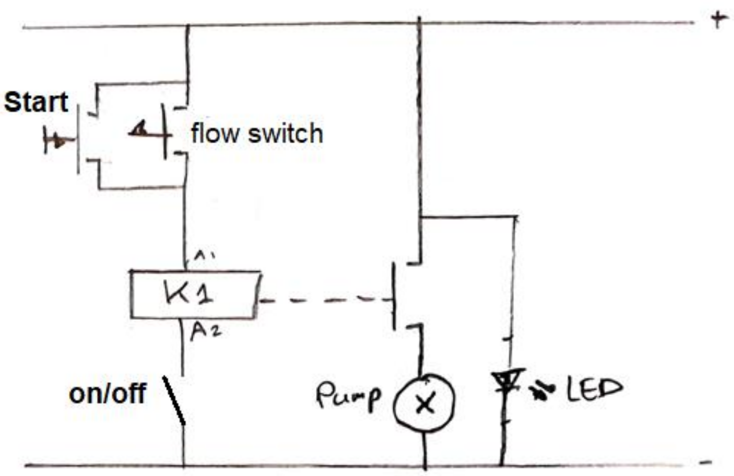
You can add an on/off switch and indicator lights to show the user if the pump had a problem and that it needs to be restarted. A possible protection system looks like this:

< Pump stopped and need to press (re)Start

Pump works normal **>**

There is an electrical design for the wiring of this simple protection box in the appendix.

This diagram below is different and has a light when the pump is working correctly. The light will stop when the pump stops. A push button will (re)start the pump.



Also see appendix "7.3 Pump protection box " page 15

3.3 Suction filter

As mentioned above most submersible electrical pumps do not like sand or other particles. Hand pumps like the rope pump and some heavy-duty centrifugal pumps with oversized impellors can handle a bit of sand.

The position of the pump in the borehole or well must be so that there is minimum chance for the pump to suck in sand. Do not place the pump at the bottom of a well or borehole If possible place the pump intake at a place where the sassing has no slots. See also appendix.

Also it is important that eventual sand in the outlet pipe, will not clog up the pump when the pumps stops. If you are not sure which side is up, then it is good to open the pump and see what side is up so that sand falls out of the mechanism as much as possible.

It is strongly recommended that the pump has an suction filter. Larger submersible pumps already have this but the small solar pumps do not have this.

You can make a suction filter as follow:

- It is essential that water passes slowly through the filter openings (< 7m/s). Because when water flows faster, it can drag sand with it. If water flows slowly, sand will fall down and will not be pulled into the filter. Therefore a filter needs to have as many small entry holes as possible and the internal diameter needs to be also big. Because the speed of water in a narrow pipe will be higher compared to the same amount of water passing through a big diameter pipe.
- Make many fine slots in the PVC pipe with a used hack saw. This will stop the sand particles larger than 1 mm.
- In case of very fine sand put a filter cloth around the suction filter / PVC pipe. But this type of cloth must be strong and be cleaned regularly. Because if it clogs then there will be only a few places where water can pass and therefore the speed of water at these (still) open places will be so high that even bigger sand particles can damage the cloth and go through. In sort it is not automatically better to add cloth, only add it if the pumps seems to have problems with fine sand.
- It might be useful to learn if sand has been entering a filter. You could have a part at the bottom that collects sand that is falling down in the filter. This part will also prevent the slots to touch the bottom of the borehole.

4 Solar panel size

Check the pump specification: 110 or 220 Volt AC or a 12, 24, 36, or . . . Volt DC .

If you use and AC pump combined with solar panels you need an inverter, a battery and charge controller between panel and pump. Sometimes inverter and charge controllers can be combined in one unit.

If the customer wants to combine the solar system for the pump with lighting or other electricity use, it is suggested to seek advice from a solar expert in designing van choosing the components.

If the solar panel(s) are only used for the pump then: Check how many watts the pump needs and buy a panel that is 25-40% more than the wattage of the pump. This because most panels deliver less than indicated on the data plate. Also there will be losses If you use 2 or 3 pumps you need to add the wattage of all pumps together and add 25%-40%. Watch out, many panels are of low quality. Try to find the best quality by checking the details. Low quality panels often have plates that are not straight, rough weldings, errors in the English spelling etc.

Some DC pumps (for example https://www.bldcpump.com and https://www.zldcpump.com) can be connected direct to the solar panel without the need for an inverter, battery or charge controller. The voltage of the pump must be as near to the panel voltage as possible. Common solar panels of 12 Volt in reality give 18 Volt output if they are connected to a load.

If panels are overloaded for instance a 80 Watt pump on a 60 Watt panel, the outlet voltage will drop. Pumps of 12 Volt and 24 Volts DC can be connected to a solar panel of 18 Volt. A pump of 12 Volt will be more efficient and has less risk of burning since windings are thicker. A protection box as described above is still a good idea to protect a pump.

5 Size of wire and electrical components

Watt = Volt X Amps.

DC pump normally run on low voltage. Meaning the Amps need to be high to get the same Watts. For instance a 12 Volt DC pump of 50 Watt needs 50 W /12 V= 4 Amps. A pump of the same power running on 240 V AC requires 50W/250V = 0.2 Amps.

High Amps in a thin wire is like pushing a lot of water through a tiny pipe. It results in high friction and resistance. Therefore high Amps demands better connections and switches and thicker wires. This is why even small DC pumps require a high Amps relay in the protection box. It is also important to make sure wires are as short as possible.

If you use thin wires because you think it is a small pump with a low voltage, then you are making a big mistake. If wires are too thin most of the power from your panel will go into heating the wire and parts of the electrical system might even burn.

The thickness of the wires can be calculated at for example: https://photovoltaic-software.com/solar-tools/dc-ac-drop-voltage-calculator

Fill in the voltage, the Watts and the length of the wire (single run). Select for example a 2.5mm² wire and see in the "DC Energy losses" is less than 10%. If so, you can use 2.5 mm² wires otherwise increase to 4 mm² and check again.

Rule of thumb

To simplify the wire design: Calculate the Amps that have to run through the wire

Amps = Watt (pumps) / Volt (panel or battery)

Systems using 3.5 Amps or less (50 watt at 14 Volt DC):

- Systems using 3.5 Amps or less can use 2.5mm² wires if the one way length of the wire is less than 15 meters.
- If the systems using 3.5 Amps or less and the one way wire length is between 15m and 30m then you can use double 2.5mm² (=5 mm²) wires.

Systems using between 4 and 7 Amps (50 to 100 Watt at 14 Volt DC):

- Systems using between 4 and 7 Amps can use 2.5mm² wires if the one way length of the wire is less than 10 meters.
- If the Systems using between 4 and 7 Amps and the one way wire length is between 10m and 20m then you can use double 2.5mm² (=5 mm²) wires.
- If the Systems using between 4 and 7 Amps and the one way wire length is between 20m and 25m then you can use 6mm² wires.

For bigger systems or longer wires

For bigger systems or longer distances, it is good to use https://photovoltaic-software.com/solar-tools/dc-ac-drop-voltage-calculator to calculate the economic required wire size.

In general a bigger wire is never bad, but there comes a point that the extra costs are not benefitting the system.

6 Size of pipe

Small diameter pipes will cause more friction because water has to pass in a higher speed through them. The bigger the flow of the pump (more water per minute) the bigger your pipe must be.

Just like with wiring, the bigger the better, but at some point, there is no extra gain from a bigger pipe or wire and it only costs more.

Rule of thumb

If your customer needs a long pipe, the cost of the pipe becomes a bigger part of the project and it is good to have an expert assist you in calculating the most economically efficient pipe size.

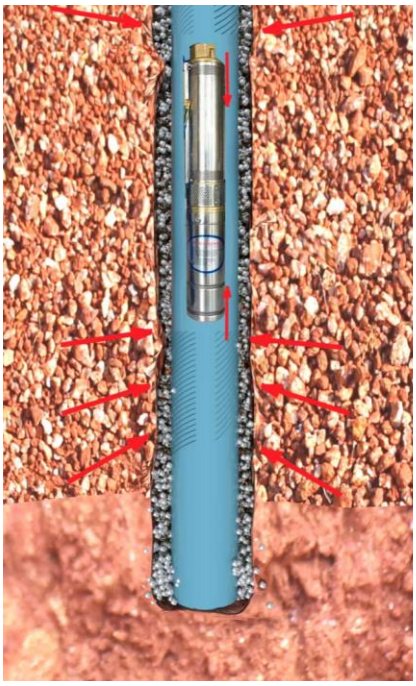
To make thinks easy we suggest:

- use 20mm (1/2") pipes for systems with 20 Litre/minute or less flow rate.
- use 25mm (3/4") pipes at flow rates between 20 L/min and 50 L/min.
- use 32mm (1") pipes at flow rates between 50 L/min and 100 L/min.

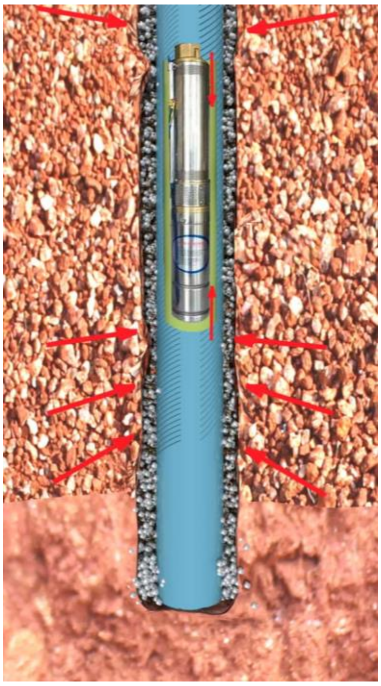
7 Appendix:

7.1 Where to install a submersible pump in a borehole

The place where the pump sucks water should not be at a place where there are slots in the casing. Otherwise the pump will pull sand through the gravel pack and it will destroy the pump.



In designing the casing, the drillers have to make sure there is a place to hang the pump where there is no filter screen for example 2 meters. And the drillers must make an exact drill log showing where to place the pump. A common mistake is that lengths of connection sockets where pipes overlap or not considered.



If the casing is slotted all the way and there is not a good place to hang the pump than you could try to use a sleeve pipe over the pump forcing the water to be sucked not at the side of the pump but at the top and bottom of it. A sleeve pipe is a bit bigger than the pump but still fits loosely in the casing. The sleeve pipe is connected to the pump.

7.2 DC pumps with and without Brushes

There are a great number of different small and affordable DC pumps on the market.

SMART Centres have been testing a number of them and concluded:

That pumps with brushes (like common fuel pumps for cars) are very cheap (for example $4) and have surprisingly good pump characteristics. However the live span if limited. Most of the pumps with brushes start leaking water in the brush department and although voltage is low, the wires are damaged when water touches it. Some pumps could pump few a month or two.

Brushless pumps use a permanent magnet and some smart electronics instead of brushes. Therefore the water departments are completely separated from the electrical parts and the pumps last much longer. Brushless pumps have been running in tests constantly for over a year. They cost a bit more (for example 35$) but we believe it is money well spent.

Some brushless pumps have (inbuild) controlers that make the pump work in 3 phase instead 1 phase. Theses are normaly more efficient. For example www.bldcpump.com.

Also interesting to know is that for example www.zldcpump.com provides pumps that are very easy to put in series with threaded in and outlet.

7.3 Pump protection box scheme