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Solar pipe sizing

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Introduction

The size of the solar pipework to and from the solar collectors will depend on a number of factors. These are the key issues.

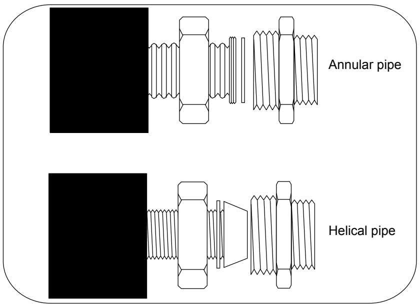
1. The type of pipework used
2. The type of solar pump and pump set
3. The type and number of heat exchangers used and how they are installed
4. The number and type of solar collectors and how they are installed

helical pipe & assorted fittings

Pipework types

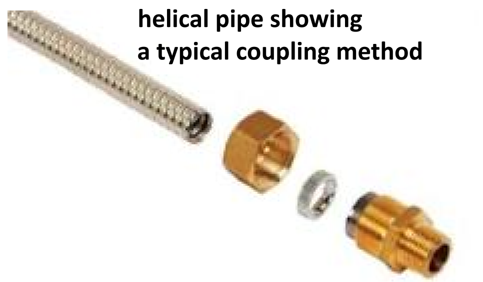
The first point to make is that because of the extremely high temperatures encountered in solar systems, traditional soft solder joints cannot be used. The difficult sets and bends required and installation time are additional factors.

Having said that, there are several types of pipe available that can be used to link the heat exchanger to the collectors. It's worth emphasising that all pipework and fittings must be solar rated. The generally accepted method is to use a flexible, high temperature annealed stainless steel pipe system. For the purposes of this document, we shall be using the Intaeco stainless steel flexible pipe products. These are available in two different types as shown in the diagram below.



Most commonly used is the 'Annular' design, which has a series of parallel corrugations giving it flexibility. A series of flange faced fittings are available for different applications as well as a tool to create the flange face.

For maximum efficiency however, 'Helical' pipe is the preferred choice. Very easily fitted, the inbuilt flexibility is achieved by its spiral configuration. This eliminates the dead flow areas in the pipe created by the corrugations, and significantly increases achievable flow rates through the pipework. This means that the pipe can, in some cases, be of a smaller diameter than you might expect, providing reduced heat loss due to the smaller surface area. Unlike the annular system, with helical pipe, a range of fittings can be used to make connections between the pipes, eliminating the requirement for special tools with which to make flanged joints.



helical pipe showing a typical coupling method

Made from annealed stainless steel grades 316 and 304, there is also less springiness in the pipe, making accurate and neat formation easier to achieve. The installer doesn't have to over-compensate particularly when forming bends. Flexible pipework also absorbs thermal expansion, removing the need for expansion joints at the collectors.

For many installations, a one piece pipe run between the collector and the pump station removes the risk of leaks, either at the time of installation or later, when pipework has settled or undergone system expansion and contraction.

K-flex EPDM pre-insulated pipe

The pipe can be supplied in coils, or in pre-insulated twin pipe packs to set lengths. Being pre-insulated also offers other benefits, which can only be appreciated by those who have spent frustrating hours pushing metres of pipe through long lengths of the specially designed lagging normally specified for Solar installations.

Collector sensor cables can also be integrated into the insulation, making pipe and cable routing a single process. Where the collector sensor cable is integrated into the insulated piping, it provides added peace of mind as the insulation material provides additional protection to the cable.

Solar pump and pump sets

There are many different types of solar pump sets available and most function in similar ways.

Those most frequently used are the single and twin line pump sets. The additional components of the twin line sets produces more resistance through them. Where single line sets are used, care should be taken to allow for the additional pressure drop created by the extra valves in the return leg from the collectors.

continued overleaf

Many of the pump sets that are available have the option of two or three different models of solar pump. Obviously, the larger the pump, the greater the mass flow and head it will be able to generate, but the more energy it will consume. So, in some applications, there will be a trade-off between pump size and pipe size.

If the pipework is over-sized, this will lead to more heat loss in the pipework than is desirable. On the other hand, if the pump is sized to overcome the pressure drop caused by under-sized pipework, this will lead to more electrical energy being used to drive the pump, as well as possible noise and erosion problems in the pipework because of the greater velocities.

Heat exchangers
The type of heat exchanger used i.e. internal coil/heater battery type or external plate heat exchanger/shell and tube version will affect the overall pressure drop through the system that the solar pump will have to overcome. Some complex solar cylinders have two solar coils which can be piped in series during periods of high solar yeild. Similarly, the high temperature coil can be by-passed during periods of low solar gain or when the high temperature part of the cylinder is satisfied.

This is usually achieved through a suitable motorized valve, but the pressure drop during series flow must be accounted for.

Where external heat exchangers are used, they can be sized to suit the requirements of the system. Typically, the pressure drop through the heat exchanger should be kept within 15kPa.

Solar collectors
Another variable to account for when correctly sizing the equipment, are the solar collectors. There are many different types available and all have a minimum flow requirement which should be adhered to. Some of the “meander” type flat plate collectors are suitable to work under low-flow conditions - typically 15 litres per hour/m^2.

This type of collector has a number of benefits over other high flow type collectors, but the main advantages are that higher temperatures can be reached from the collectors. This gives the designer more options in terms of application.

Where low-flow systems are installed, the solar pipework can be kept to a minimum as the pressure losses at the lower flow rates will be considerably reduced compared to a high flow system.

For large solar thermal applications, the solar collectors are usually made up of several collectors piped in series, and these arrays are linked in parallel.

When considering the pressure drop through the total solar array, you should also consider the total flow through all of the collectors and the pressure drop through the largest array. It’s also worth mentioning at this point that although the pressure drop through the maximum allowed directly coupled collectors may be relatively low, this is more to do with the thermal expansion of the collectors than the hydraulic resistance through them.

Flow rates
As mentioned earlier, the flow rates required within the system are dependant on the limitations of the components and the application of the system. The higher the desired collector exit temperatures, the lower the flow rates should be through the system. It is therefore important to choose the correct components for the specific application.

There are three basic types of flow system available to the designer of any solar heating system.

1. Low flow
2. High flow
3. Matched flow

The type of system is determined by the specific volumetric flow rate in relation to the solar collector area (litres per hour/m^2).

continued overleaf

For “low flow” systems, this value lies in the range between approximately 15 and 20 litres per hour/m^2. The designer should ensure that the minimum flow rate through the collector as specified by the manufacturer is achieved.

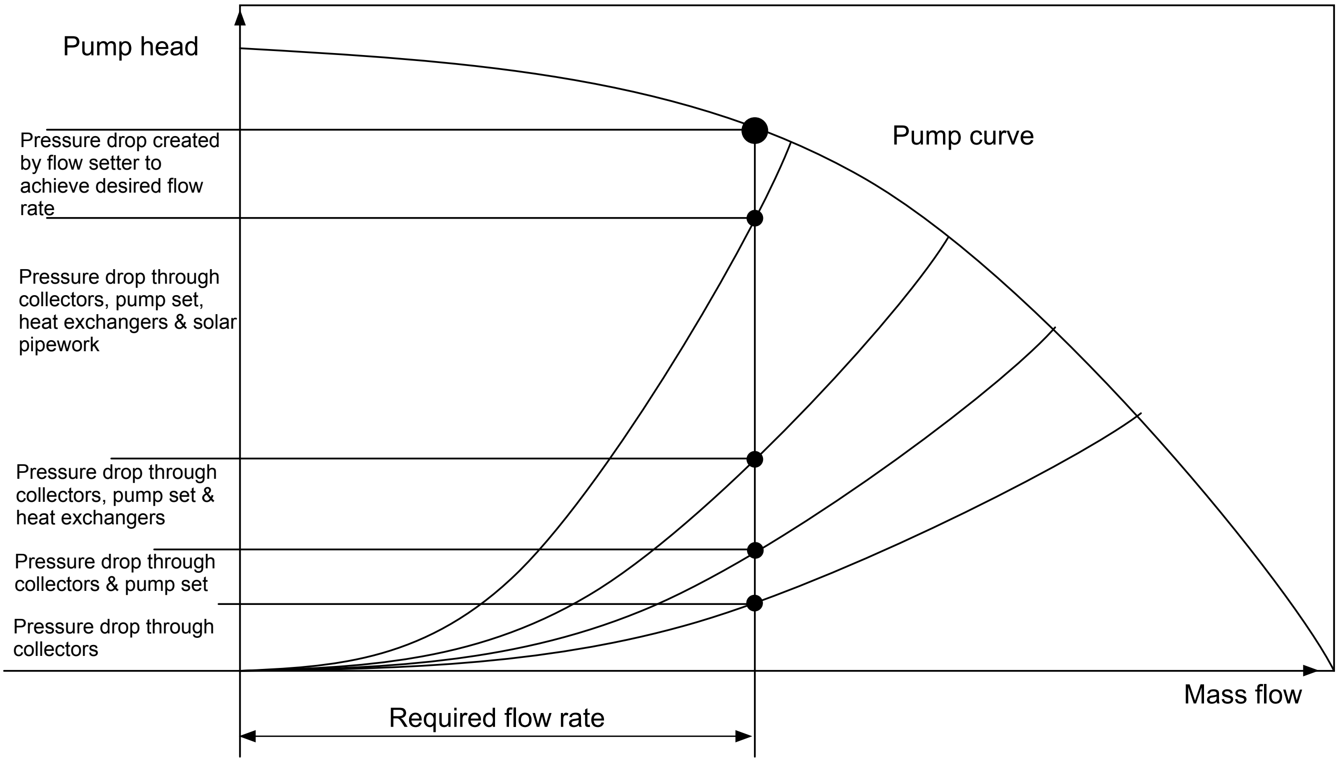
This could be by the connection, in series, of several collectors. This is important as otherwise, the flow through the collectors could lead to localised hot spots due to dead legs. On the other hand, it must also be noted that the flow through an individual collector can be very high when the collectors are connected in series. Therefore, the upper limiting value for the collectors must also be adhered to. Greater volumetric flow rates based on the whole collector array (normally above 30 litres per hour/m^2) are designated as “high flow”.

The term “matched flow” describes variable volumetric flow rates which are governed by variable speed pumps in the range between high flow and low flow. This is usually achieved by using a suitable solar system controller witrh a pump speed control feature on it.

Equipment specifications
Once the system flow rate has been calculated, and you have selected the size and type of collector array and the type of consumer(s) required, you can select the pump set and the solar pipework for the system.

It’s recommended that the velocity in the main pipes from the solar pump station are at least 0.4m/s and typically, up to 1m/s velocities are acceptable. This can be determined by the length of run required from the collector array down to the pump set. It’s also recommended that a margin of error is built into the design to allow for any unforeseen bends or valves. A figure of around 10% should be used as a guideline as this can easily be accounted for by the flow setter in the solar pump set.

Pressure losses within a typical solar thermal system
The diagram below represents the typical compinents within the system which create pressure losses during operation. Like all pumps, the operating characteristics will always fall somewhere on its performance curve. It is the job of the flow setter or regulating valve to create the final adjustment.



Annular Piping Systems (Pressure drop and Flow Rates)

DN16

pressure drop (bar/m)	flow rate (ltrs/m)
1.44	2.13
2.28	2.67
3.30	3.07
4.52	3.40
5.96	3.78
7.57	4.15
9.39	4.62
11.29	5.30
13.49	5.59
15.81	6.04
18.18	6.48
20.89	6.88
23.64	7.26
26.60	7.60
30.02	7.91
33.23	8.33
36.79	8.65

DN20

pressure drop (bar/m)	flow rate (ltrs/m)
1.40	2.68
2.24	3.25
3.26	3.62
4.48	4.36
5.75	4.97
7.48	5.29
9.30	5.80
11.25	6.16
13.36	6.75
15.73	7.29
18.27	7.69
20.89	8.12
23.76	8.65
26.77	9.08
29.89	9.45
33.28	10.07
36.74	10.69

DN25

pressure drop (bar/m)	flow rate (ltrs/m)
1.30	5.66
2.13	7.07
3.11	8.49
4.26	9.39
5.56	10.73
7.14	11.87
8.90	12.91
10.75	14.20
12.79	15.09
15.02	15.86
17.38	16.37
19.88	17.35
22.57	19.91
25.49	20.71
28.50	21.91
31.89	22.58
35.18	23.79

DN32

pressure drop (bar/m)	flow rate (ltrs/m)
1.06	9.37
1.80	11.85
2.53	13.92
3.59	15.95
4.74	17.98
6.05	20.98
7.60	23.01
9.23	24.67
10.95	26.95
12.87	30.10
14.99	32.17
17.24	34.59
19.61	36.68
22.14	38.77
24.84	40.73
28.43	43.14
31.78	45.24

Helical Piping Systems (pressure drop and flow rates)

DN15

pressure drop (bar/m)	flow rate (ltrs/m)
1.30	2.20
2.17	2.60
3.09	3.12
4.26	3.47
5.65	3.89
7.22	4.30
8.83	4.68
10.74	5.02
12.79	5.44
15.00	5.82
17.35	6.29
19.92	6.83
22.53	7.18
25.48	7.49
28.53	7.81
31.75	8.44
34.79	8.87

DN20

pressure drop (bar/m)	flow rate (ltrs/m)
2.04	5.49
2.78	6.68
3.80	7.77
4.96	9.05
6.35	10.19
7.97	11.26
9.64	12.54
11.59	13.67
13.72	14.63
15.90	16.04
18.54	16.59
21.00	18.09
23.73	19.09
26.79	20.44
29.85	21.40
32.44	23.02
36.15	24.50

DN25

pressure drop (bar/m)	flow rate (ltrs/m)
1.16	9.59
1.95	11.97
2.87	13.96
3.99	16.24
5.19	18.35
6.63	20.55
8.34	22.73
10.10	25.33
11.96	27.10
14.09	29.25
16.41	31.87
18.82	34.62
21.41	36.66
24.31	38.55
27.21	40.99
30.36	42.83
33.83	45.05

DN32

pressure drop (bar/m)	flow rate (ltrs/m)
0.94	15.15
1.50	19.46
2.29	23.96
3.18	28.38
4.26	34.26
5.48	39.03
6.83	43.30
8.33	47.57
10.11	52.02
11.89	56.74
13.81	61.19
15.91	65.15
18.16	69.32
21.06	74.81
23.21	78.73
25.88	82.61
29.02	87.04