

Solar Pipe Sizing.

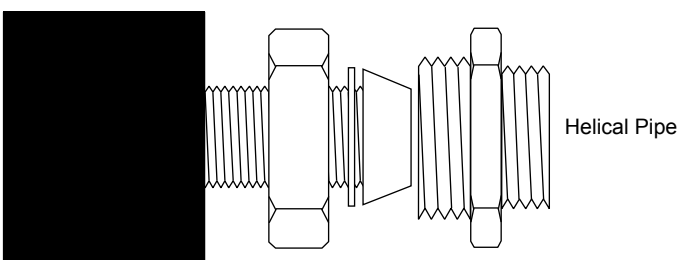
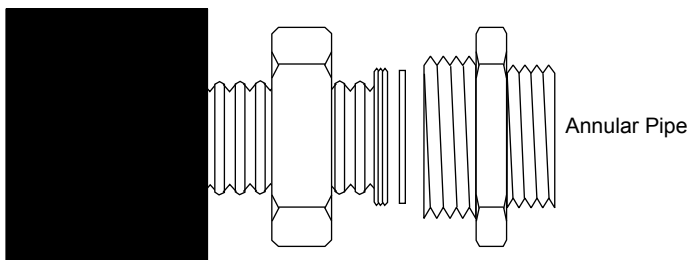
The size of the solar pipe work to / from the solar collectors will depend on a number of factors:

- 1) The type of pipework used,
- 2) The type of solar pump and pump set,
- 3) The type and number of heat exchanger(s) used and the way they are installed,
- 4) The number and type of solar collectors and the way they are installed,
- 5) The flow rates required.

The type of pipework used.

The extreme temperatures, difficult sets and bends required and installation time dictate that the use of copper tube with traditional soft solder is not a suitable approach to piping up a solar thermal system. There are a number of types of pipe on the market that can be used to link the collectors to the heat exchanger. It is imperative that all pipework and fittings must be suitable for the high temperatures that can be experienced in solar systems, especially during times of stagnation. The generally accepted method is to use flexible, high temperature annealed stainless steel pipe systems. For the purpose of this document we will be looking at the IntaEco stainless steel flexible pipe systems. These are available in two basic types:

- 1) Annular
- 2) Helical



The most common used of these is the annular design, which has a series of parallel corrugations giving it its flexibility. A series of flanged face fittings are available for many different applications and a tool to simply create the flange face.

The more efficient design is however "Helical", where flexibility is achieved through a spiral configuration. This eliminates the dead flow areas in the pipe created by the corrugations and thus significantly reduces the pressure losses through the pipe. This can result in a smaller diameter pipe being used, which has the added benefits of lower heat losses due to a smaller surface area, less expensive pipe, insulation and fittings. Unlike the annular pipe systems with the helical system joints can be made without the need for the flange facing tool.



Made from annealed stainless steel grade 316 and 304 reduces the amount of springiness in the pipe and this makes accurate and neat pipe

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formation much easier as the installer doesn't have to over compensate when forming bends. Another additional benefit to the flexible pipework is its ability to absorb thermal expansion, which removes 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.



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

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

The type of solar pump and pump sets.

There are many different types of solar pump sets on the market but most do predominantly the same function. The main two types most frequently used are the single line and the twin line pump sets. Due to the additional components the twin line sets have more resistance through them, however where single line sets are used care must be taken to allow for the additional

pressure drop created by the extra valves in the return leg from the collectors.

Many of the pumps sets available have the options 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 oversized this will lead to more heat loss in the pipework than is necessary, on the other hand if the pump is sized to overcome the pressure drop through undersized pipework this will lead to more electrical energy used to drive the pump and possibly noise / erosion problems in the pipework if the velocities are too great.

The type and number of heat exchanger(s) used.

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 yield or the high temperature coil can be bypassed during periods of low solar gain or when the high temperature part of the cylinder is satisfied. This is done 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.

The number and type of solar collectors.

One of the other variables to account for when sizing the correct equipment is the solar collectors. There are many different types on the market 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, this is typically 15 litres per m² per hour. This type of collector has a number of benefits over other high flow type collectors, but the main advantages are

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that higher temperatures can be reached from the collectors and so 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 less than found in a high flow system.

For large solar thermal applications the solar collectors are usually made up of a number of arrays 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 consider the total flow through all of the collectors and the pressure drop through the largest array. It is also worth mentioning at this point that although the pressure drop through the maximum allowed directly coupled collectors may be relatively low, the reason for the limitation is more to do with thermal expansion of the collectors than the hydraulic resistance through them.

The flow rates required

As mentioned briefly 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. Therefore it is important to choose the correct components for the application. There are three basic types of flow system available to the designer of a 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 (l per hour and per m²). For low flow systems this value lies in the range between approximately 15 and 20 litres per hour / m². The designer should ensure that the minimum flow rate through the collector as specified by the manufacturer is achieved. This could be by the series connection of several collectors. This is important as otherwise the flow through the collectors could lead to localized 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 / m²) 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 with a pump speed control feature on it.

Equipment Specification

Once you have calculated your flow rate for the system and 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.

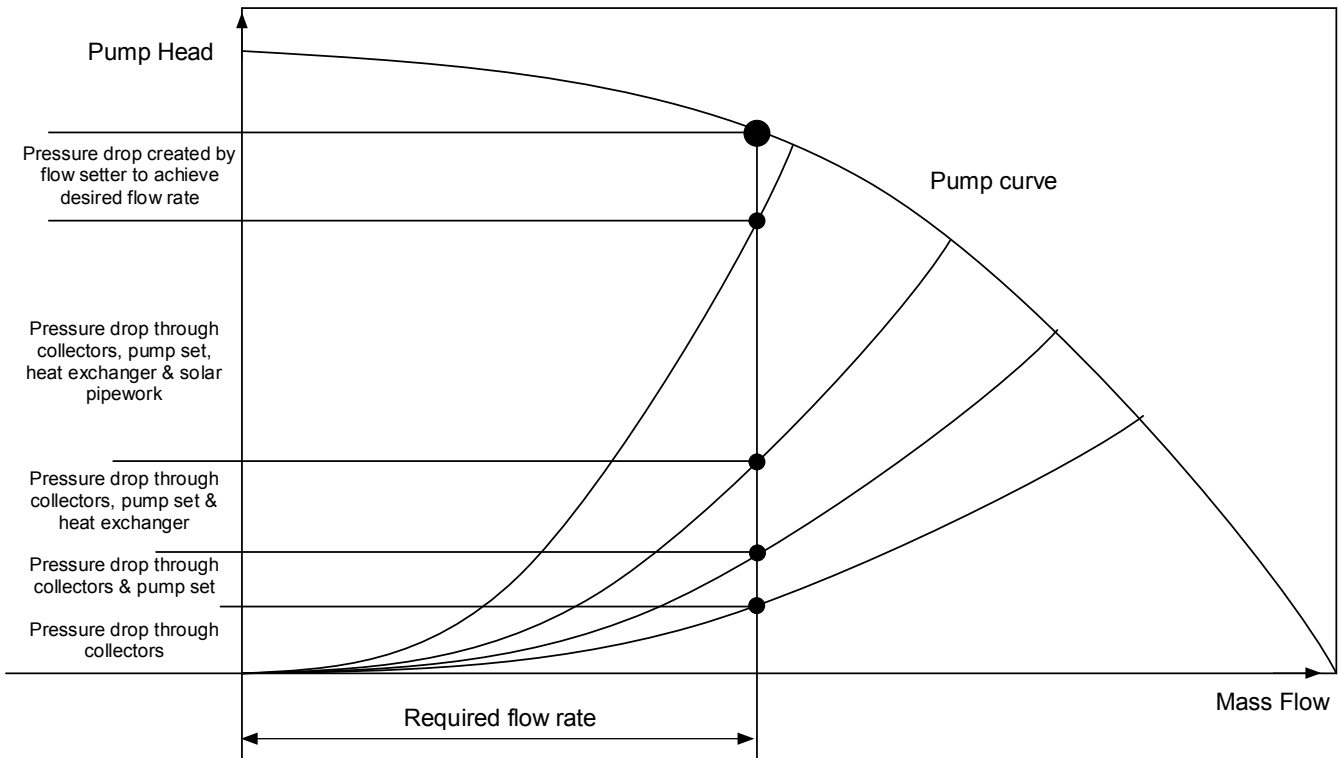
It is recommended that the velocity in the main pipes from the solar pump station are at least 0.4 m/s and typically up to 1m/s velocities are acceptable. This can be determined by the length of run required from the collector array down to the pump set. It is also recommended that a margin of error is built into the design to allow for any unforeseen bends / 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.

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The pressure losses within a typical solar thermal system.

The diagram below represents the typical components within the system that create the 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.



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Annular Piping Systems (Pressure drop and Flow Rates)

DN16

pressure drop (mbar/m)	flow rate (l/min)
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 (mbar/m)	flow rate (l/min)
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 (mbar/m)	flow rate (l/min)
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 (mbar/m)	flow rate (l/min)
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

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Helical Piping Systems (Pressure drop and Flow Rates)

DN15

pressure drop (mbar/m)	flow rate (l/min)
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 (mbar/m)	flow rate (l/min)
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 (mbar/m)	flow rate (l/min)
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 (mbar/m)	flow rate (l/min)
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