Technical Information

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Dimensions of plastic piping systems

Dimensional comparison

A wide range of thermoplastic piping systems, are available in both inch and metric dimensions. In all such cases, the outside diameter (O.D.) is a strictly controlled dimension fixed by internationally recognised manufacturing standards. The inside diameter changes according to the material, its wall thickness, and the pressure rating and therefore it is given a nominal dimension only, referred to as the nominal bore (N.B.).

Errors can occur both with the interpretation of the dimensional standards and in the definition of the required size. In general terms, systems of the same material made to either inch or metric sizes are not dimensionally compatible, except (for some materials) 2 1/2" pipe which has the same outside diameter as 75mm pipe, and 5" pipe which has the same outside diameter as 140mm pipe. Transition fittings are needed to connect between inch and metric sized systems in all other dimensions.

Care needs to be taken to use a clear definition of the pipe size being used. Inch systems are always referred to using their nominal bore dimension (measured in either inches or mm). Metric systems, whilst always measured in millimetres, are usually described by the outside diameter (O.D.) or occasionally by their nominal bore dimension (DN), which is always expressed in millimetres. The following table shows a comparison between the approximate equivalent inch and metric sizes:

Inch System			**Metric System**	
Nominal Bore	Outside Diameter		Nominal Bore (DN)	Outside Diameter
	British Standard	ASTM		
(inch)	(mm)	(mm)	(mm)	(mm)
			8	12
3/8	17.1	17.1	10	16
1/2	21.4	21.4	15	20
3/4	26.7	26.7	20	25
1	33.6	33.6	25	32
1 1/4	42.2	42.2	32	40
1 1/2	48.3	48.3	40	50
2	60.3	60.3	50	63
2 1/2	75.2	73.0	65	75
3	88.9	88.9	80	90
4	114.3	114.3	100	110
			110	125
5	140.2	141.3	125	140
6	168.3	168.3	150	160
			175	200
8	219.1	219.1	200	225
			225	250
10	273.0	273.0	250	280
12	323.9	323.9	300	315
14	355.6	355.6	350	355
16	406.4	406.4	370	400

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Sizing pipes

It is possible to calculate an approximate pipe size for a given flow rate using the following formula:

$$d_i = 35.7 \sqrt{\frac{Q}{v}}$$

where
v = Flow velocity (m/s)
d_i = Pipe inside diameter (mm)
Q = Flow rate (l/s)

It is quite common for the flow velocity to be unknown at this stage. The following values are regarded as acceptable liquid velocities for plastic systems:

Suction = 0.5 - 1.0 m/s
Delivery = 1.0 - 3.0 m/s

Example:
What will be a suitable size for a pipe carrying water at a flow rate of 100 litres per second with a flow velocity of 1.5 metres per second?

$$d_i = 35.7 \sqrt{\frac{100}{1.5}}$$

$$d_i = 291 \text{ mm}$$

Therefore the optimum internal diameter should be 291 mm (minimum). Selecting a pipe with an internal diameter smaller than the optimum size will create increased pressure drop.

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Pressure loss in pipe

Flowing media in pipes causes pressure loss, and energy loss within the piping system. The important factors for the calculation of the extent of the pressure loss in a piping system are as follows:

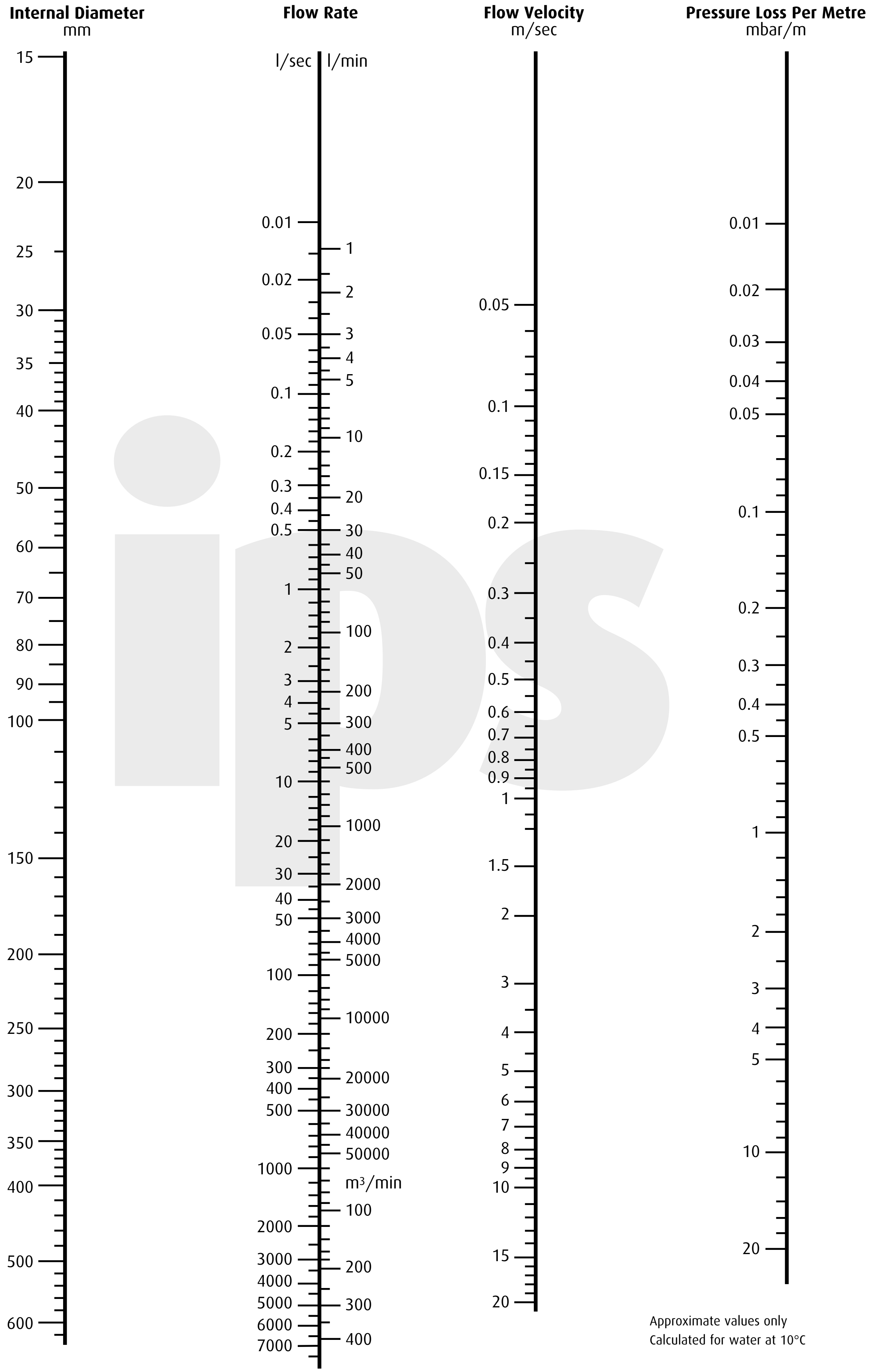
- pipe length
- pipe cross section area
- roughness of the pipe surface
- the geometry of fittings and joints
- the viscosity and density of the flowing medium

The total pressure loss in a piping system is the result of the sum of all the individual pressure losses above. By using simple calculation methods, it is possible to quite accurately forecast the total system pressure loss. However, it is usually necessary only to approximate this value using the flow nomogram on the following page.

To calculate pressure drop using the flow nomogram:

1. Note the internal diameter in millimetres of the pipe being considered.
2. Mark this diameter on the scale headed “Internal Diameter”.
3. Mark the required flow rate in litres per second on the scale headed “Flow Rate”.
4. Draw a straight line to connect these two points and extend this through the next two scales.
5. The velocity of flow in metres per second can be read at the point where the line intersects the scale headed “Flow Velocity”.
6. The frictional pressure drop in mbar per metre can be read at the point where the line intersects the scale headed “Pressure Loss Per Metre”.

Flow Nomogram



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Pressure loss in fittings and valves

Pressure loss in fittings

Where the system is complex and intensively uses fittings and changes of direction, it is also possible to approximate the effect on head loss due to the fittings. The following table can be used as a guide to the equivalent pipe length (in metres) for four of the commonly used pipe fittings:

Nominal Size	1/2(15)	3/4(20)	1(25)	1 1/4(32)	1 1/2(40)	2(50)	3(80)	4(100)
Tee (Run)	0.30	0.43	0.52	0.70	0.82	1.22	1.86	2.41
Tee (Side Outlet)	1.16	1.49	1.83	2.23	2.56	3.66	5.00	6.70
90° Elbow	0.46	0.61	0.76	1.16	1.22	1.74	2.41	3.48
45° Elbow	0.24	0.34	0.43	0.55	0.64	0.79	1.22	1.55

Nominal Size	6(150)	8(200)	10(250)	12(300)	14(350)	16(400)	20(500)	24(600)
Tee (Run)	3.75	4.27	5.33	6.10	7.62	8.23	10.67	12.80
Tee (Side Outlet)	9.97	14.94	17.38	20.43	23.78	26.83	35.98	41.77
90° Elbow	5.09	6.40	7.93	9.76	11.28	13.11	17.68	20.43
45° Elbow	2.44	3.23	4.12	4.73	5.49	6.10	7.62	9.15

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Pressure loss in fittings and valves

Pressure loss in valves

All thermoplastic valves have a flow factor that is normally described as a K_v value. K_v values are an established means of defining the flow rate in m^3 per hour of water at 20°C through a fully open valve, with a pressure drop of $1kg/cm^2$.

The C_v value is a commonly referenced flow coefficient for valves manufactured in the U.S.A. It is defined as the flow of water through a valve at 60°F (15.54°C) in US gallons per minute, with a pressure drop of 1 psi.

The connection between Flow Factor K_v and Flow Coefficient C_v can be expressed as:

$K_v = 0.86\ C_v$
$C_v = 1.16\ K_v$

The K_v value is also the sizing factor to calculate the pressure drop ($\triangle p$) in bar of a liquid flow across the valve:

$$\triangle p = \frac{\delta \cdot Q^2}{K_v^2}$$

where
$\triangle p$ = Pressure drop (bar)
δ = Density of the liquid (kg/dm^3)
Q = Flow rate (m^3/hr)

For example, calculate the pressure drop in a 50mm DN ball valve that is 50% closed handling 90% sulphuric acid (density $1.81kg/dm^3$) at a flow rate of $12m^3/hr$:

$$\triangle p = \frac{1.81 \cdot 12^2}{51^2}$$

(the K_v value is taken from the pressure drop characteristics table below and is calculated as 204 x 25%)

$\triangle p = 1.81 \cdot 0.0554$

$\triangle p = 0.1002$ bar

If the flow, the maximum pressure drop and the density of the liquid are known, it is possible to calculate the minimum K_v value as follows:

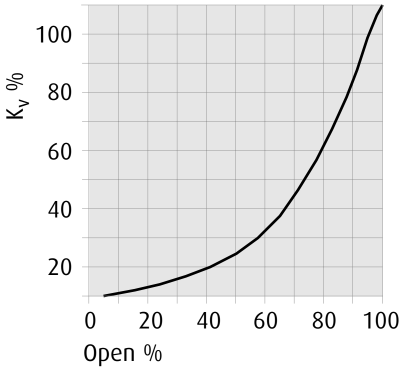
$$\text{Minimum } K_v \text{ value in } m^3/hr = Q \sqrt{\frac{\delta}{\triangle p}}$$

The K_v value for all valves can be read from the appropriate flow chart for each valve type. Kv flow charts give the flow characteristics of each type of valve, from the fully closed to the fully open position.

Typical valve pressure drop characteristics

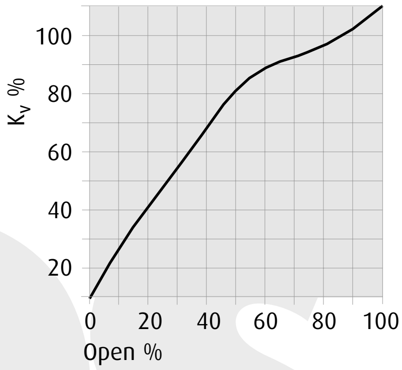
Ball Valve (2-way)

DN (mm)	DN (inch)	K_v value (m^3/hr)
15	fi	12
20	fl	23
25	1	46
32	1/	66
40	1fi	105
50	2	204
65	2fi	315
80	3	426
100	4	570



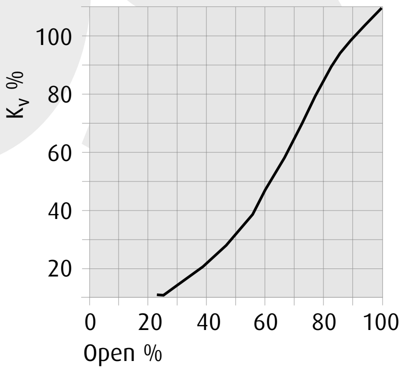
Diaphragm Valve

DN (mm)	DN (inch)	K_v value (m^3/hr)
15	fi	5
20	fl	8
25	1	10
32	1/	18
40	1fi	25
50	2	46
65	2fi	78
80	3	120
100	4	162



Butterfly Valve

DN (mm)	DN (inch)	K_v value (m^3/hr)
65	2fi	102
80	3	213
100	4	354
125	5	591
150	6	1122
200	8	1830
250	10	3800
300	12	5400



Check Valve

DN (mm)	DN (inch)	K_v value (m^3/hr)
15	fi	7
20	fl	12
25	1	23
32	1/	34
40	1fi	50
50	2	78
65	2fi	117
80	3	156
100	4	210

Line Strainer

DN (mm)	DN (inch)	K_v value (m^3/hr)
15	fi	2
20	fl	4
25	1	6
32	1/	11
40	1fi	15
50	2	25
65	2fi	39
80	3	63
100	4	102

The values shown above are average values that are typical for plastic valves. Please enquire for specific K_v values for actual valves.

System design

Water hammer

When the flow rate of a fluid in a pipe is changed, the velocity changes, causing a pressure surge. Such surges take place wherever there is a change of direction in the pipe, but potentially more seriously, they may be generated by any of the following:

- Pump start-up or shut-down
- Trapped air in the system
- Opening or closing a valve

The longer the pipeline and the faster the velocity, the greater the potential shock load will be. Commonly known as 'water hammer', the shock load can be of sufficient force to cause a failure in pipe, fitting or valve, and due consideration must be given to it when designing a system.

It is important to note that the amount of the pressure surge must be considered in addition to the existing static pressure in the pipe, and this combined total must be within the pressure handling capabilities of the chosen system.

A number of steps can be taken to reduce the incidence of water hammer in a system:

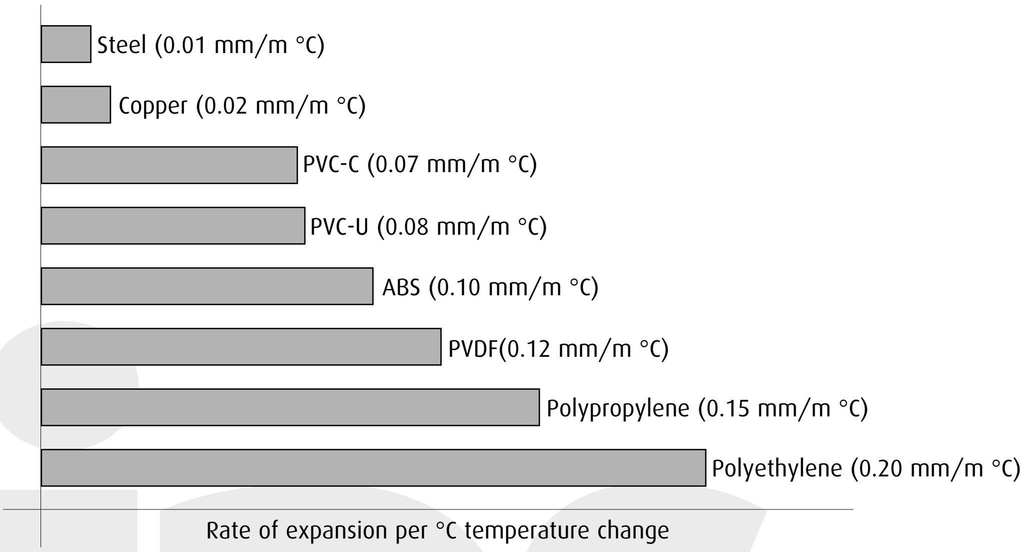
- Reduce flow velocities wherever possible, on discharge piping do not exceed 3 m/s, but preferably no more than 1 m/s.
- Avoid large, single step reductions in pipe diameter, instead use tapered reductions rather than bushes.
- Design the system to eliminate all air from the system at start-up, and include devices to prevent air accumulating during system operation.
- Eliminate the use of fast closing or opening valves.

System design

Thermal expansion and contraction

Plastic piping is subject to thermal expansion and contraction that is several times that of steel. When installed above ground and subjected to varying temperatures, this movement needs to be allowed for so that stress on the material and unsightly snaking of the pipework can be avoided.

Comparison of thermal expansion rates by material



Generally, when installing plastic piping systems that have pipe runs that exceed 30 metres and a temperature variation of over 17°C, then provision should be made for thermal expansion or contraction. The temperature at the time of installation should also be considered. A system may run indoors with, for example, an ambient and fluid temperature ranging from 18°C to 24°C, however if it was installed in winter during the construction of the building when ambient temperatures were less than 5°C, then a temperature change of at least 19°C needs to be considered.

Although plastics have the capacity to absorb some of the stresses that may be placed on the system, expansion and contraction can create problems if it is not adequately planned for. Some examples of more critical situations include: when pipe contraction can result in the pull-out of the pipe from a mechanical fitting; when movement can create excessive thrust or bending moment on fittings; when repeted movement on the same point can induce stress fatigue; or when pipe expansion creates excessive sagging.

Therefore, once calculated, provision for thermal movement must be incorporated into the system. In many cases, changes in direction that occur naturally in the piping system may be used for the absorption of the changes in length, with the help of minimum straight lengths. If this is not possible, compensation or expansion loops will need to be incorporated into the system design. Mechanical compensators, such as bellows or piston-type expansion joints may also be considered.

System design

Calculating expansion and contraction

The change in length (relative to its original length) due to temperature is expressed by the parameter "linear coefficient of thermal expansion". This parameter can be incorporated into a simple equation to calculate the change in length of a pipe for a given change in temperature.

The following formula is used:

$$\Delta L = L \cdot \Delta T \cdot \sigma$$

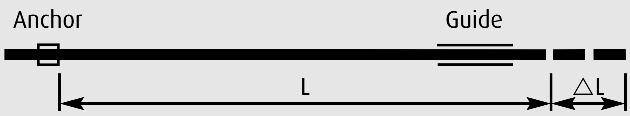
where

- ΔL = Change in length (mm)
- L = Length of pipe being studied (m)
- ΔT = Temperature change (°C)
- σ = Material coefficient of linear expansion (see below)

Coefficient of linear expansion by material(σ)

- PVC-U = 0.08 mm/m °C
- PVC-C = 0.07 mm/m °C
- ABS = 0.10 mm/m °C
- PE = 0.20 mm/m °C
- PP = 0.15 mm/m °C
- PVDF = 0.12 mm/m °C
- ECTFE = 0.10 mm/m °C

Remember to incorporate the installation temperature into the calculation if appropriate, as well as the change in operating temperatures.



A pipe anchored at one end will expand in length when subjected to an increase in temperature

Example:

An ABS straight pipe run 250metres long is installed in ambient temperature conditions of 10°C. The maximum operating temperature is 35°C. The minimum operating temperature is 15°C. How much expansion is expected?

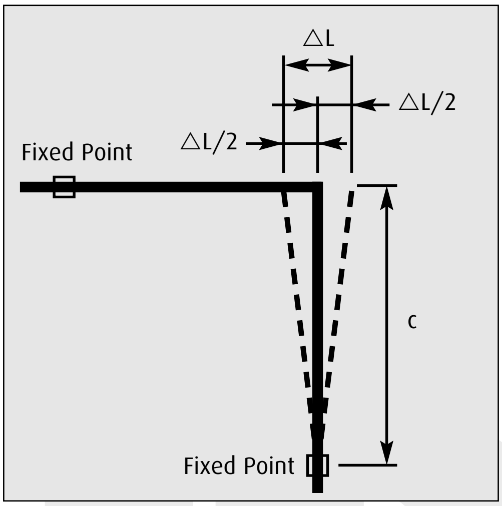
$$\Delta L = L \cdot \Delta T \cdot \sigma$$

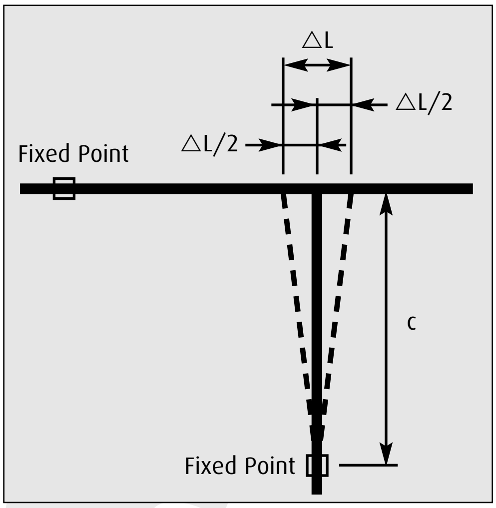
$$\Delta L = 250 \cdot (35 - 10) \cdot 0.10$$

$$\Delta L = 625\text{mm}$$

Calculating the minimum straight length

Most commonly, the alteration of the pipe length due to expansion and contraction is accommodated by changes in pipe direction. This takes advantage of the natural flexibilty of the plastic material and the high resistance to stress. Therefore in addition to a calculation to determine the minimum and maximum pipe length due to thermal expansion and contraction, the effect of this movement on the change in pipe direction needs to be considered. In particular, the “minimum straight length”, shown as the figure “c” in the diagrams below need to be calculated if undue stress on the pipe is to be avoided.





The following formula is used:

$$c = \kappa \cdot \sqrt{\triangle L \cdot d}$$

where

c	=	Minimum straight length (mm)
△L	=	Change in length due to thermal expansion (mm)
d	=	Pipe outside diameter (mm)
κ	=	Material specific constant (see table)

Material specific constant κ:

PVC-U	= 34
PVC-C	= 35
ABS	= 33
PE	= 26
PP	= 30
PVDF	= 20

For example, a PVC-U pipe with an O.D. of 50mm is run for a straight length of 50 metres before a 90° change of direction. The pipe is installed in ambient temperature conditions of 10°C. The maximum operating temperature is 20°C. The minimum operating temperature is 15°C. What is the minimum straight length?

First, calculate the change in length using the formula:

$$\triangle L = L \cdot \triangle T \cdot \sigma$$

where

△L	=	Change in length (mm)
L	=	Length of pipe being studied (m)
△T	=	Temperature change (°C)
σ	=	Material coefficient of linear expansion

Coefficient of linear expansion by material(σ)

PVC-U	= 0.08 mm/m °C
PVC-C	= 0.07 mm/m °C
ABS	= 0.10 mm/m °C
PE	= 0.20 mm/m °C
PP	= 0.15 mm/m °C
PVDF	= 0.12 mm/m °C
ECTFE	= 0.10 mm/m °C

$$\triangle L = 50 \cdot (20 - 10) \cdot 0.08$$

$$\triangle L = 40\text{mm total change in length}$$

System design

Compensating for expansion and contraction

Next, insert the value into the formula to calculate the minimum straight length:

$$c = \kappa \cdot \sqrt{\triangle L \cdot d}$$

where

c	= Minimum straight length (mm)
$\triangle L$	= Change in length due to thermal expansion (mm)
d	= Pipe outside diameter (mm)
κ	= Material specific constant (from table)

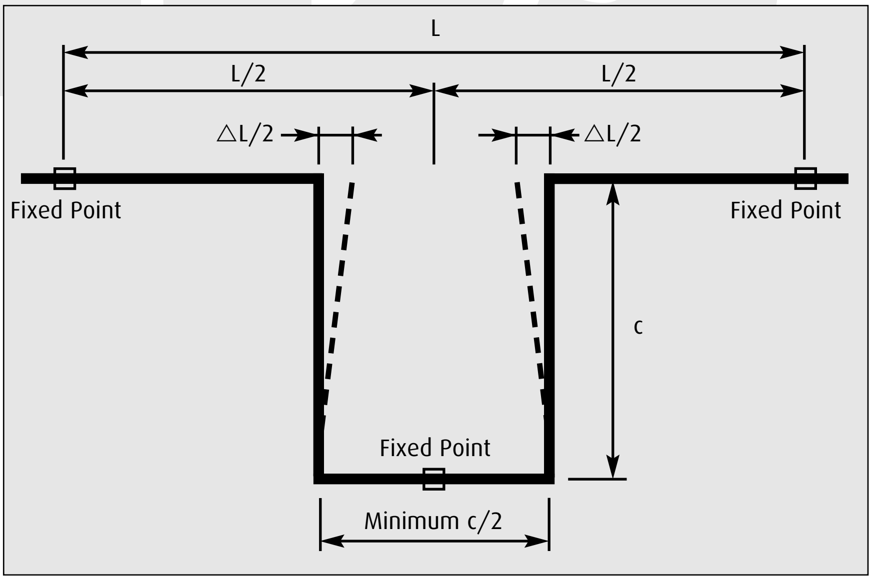
$$c = 33 \cdot \sqrt{40 \cdot 50}$$

$$c = 33 \cdot 45$$

c = 1485mm minimum straight length

Calculating the size of expansion loops

When changes of direction can not be used to accommodate expansion and contraction, it may be necessary to use an offset expansion loop. The expansion loop effectively distributes the thermal movement between two changes of direction. The size of the minimum straight length for the expansion loop is calculated using the same formula as described above.



System design

Compensating for expansion and contraction

Mechanical expansion joints

Plastic piston-type expansion joints are available in PVC-U, PVC-C and Polypropylene in diameters up to 12" /300mm (8"/200mm for Polypropylene). Travel distances vary from 150mm to 300mm.

The expansion joints are made from two pipes, one telescoping inside the other, with double O-ring seals preventing the ingress of contaminants and maintaining the line pressure. The outer part of the expansion joint must be anchored during installation, while the inner pipe is permitted to move freely as the pipe expands or contracts.

Alignment is critical with this type of joint, as any misalignment may result in binding or snagging as the pipe tries to move inside the expansion unit. Guides should be installed within approximately 300mm from both ends of each expansion joint. Pipe runs must also be anchored at calculated distances so that pipe movement is directed towards the expansion joint. Joints are usually installed with the piston partially extended, determined by the ambient temperature and the likely thermal movement.

The length of travel required for each expansion joint is calculated using the calculation formula described previously in "Calculating Expansion and Contraction".

Expansion bellows

Axial expansion bellows may be used with plastic piping, although they generally provide only a limited capacity for axial movement. However they may be useful when used to handle other movements in addition to axial, or when installation space is limited.

Expansion bellows should be installed with one end anchored securely, with the movement of the pipe directed toward the free end. If possible, a guide should be installed within approximately 300mm from the free end of the bellows.

Pipe anchors

There are a number of methods that may be used to anchor pipes, some of which are described here. However it should be noted that any method that creates stress through excessive compression (such as by tight fitting metal supports) is not recommended as damage to the pipe may occur.

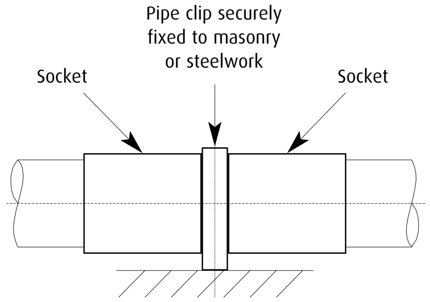
"Fixed point fittings" are manufactured from Polypropylene, Polyethylene and PVDF. They are designed to accommodate a pipe bracket that can be securely fixed to a structural support. It is also possible to fabricate this type of fitting in PVC-U and PVC-C using standard pipe sockets (see drawing).

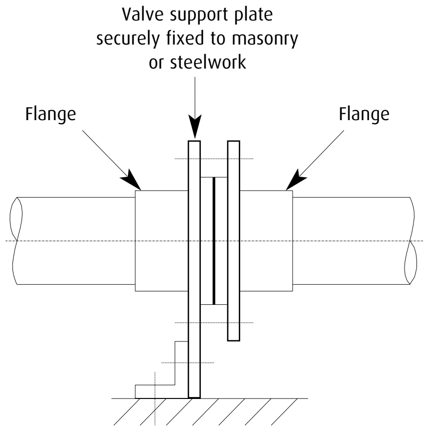
PVDF fixed point fitting shown with clip

Flanges may be also used to connect to an anchor point.

In all cases the anchor point must be capable of withstanding the forces that are created due to the thermal movement of the pipe.

Some examples of anchor point construction methods:





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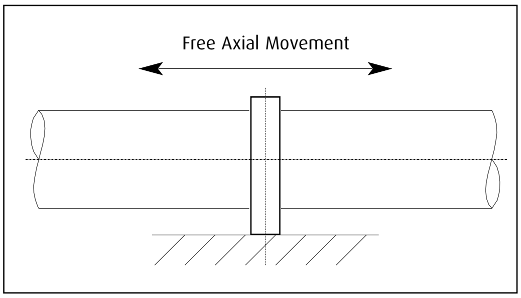
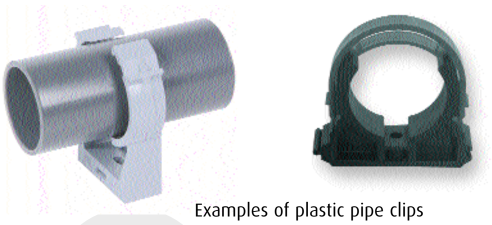
Pipe supports and routing

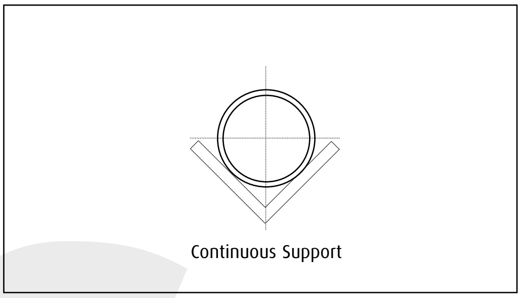
Plastic pipes have tensile strengths that are lower than those of metal pipes, therefore they will usually require additional support. In addition, the support centres for the material will be influenced by the operating and ambient temperature, the density of the fluid being transported, and the diameter and wall thickness of the pipe.



Brackets for plastic pipe should be designed to restrict lateral movement but allow the axial movement that may occur due to expansion and contraction. They should be free of snags and sharp edges that may potentially damage the pipe. Plastic pipe clips are manufactured specifically for this application, and should be used wherever possible.



Examples of plastic pipe clips



When installing small diameter plastic piping or if the piping is exposed to high operating or ambient temperature conditions it may be more cost effective to provide continuous support. U or V section metal channel is the most common method of providing a solution for this requirement.

Support centres for each material are shown on the following pages. Where the fluid density exceeds 1g/cm^3, more support will be necessary. This table gives a guide to the adjustment factor for bracket spacing within the range 1g/cm^3 to 2g/cm^3.

Fluid density g/cm^3	Adjustment factor
1.00	1.00
1.25	0.96
1.50	0.92
1.75	0.88
2.00	0.84

Pipe routing

An important factor to consider in above ground plastic pipe installations is the selection of a pipe route that avoids the risk of impact damage from external sources. Fork-lift trucks in particular can damage the pipe or pull piping from supports. Where appropriate, clear warning signs should be used advising contractors not to climb on installed plastic piping.

Particular care should also be taken to avoid routing plastic piping into areas where there may be an unusually high heat load, for example directly under glazed roof panels, at heater outlets or adjacent to hot machinery. Some plastics are susceptible to stress cracking when exposed to oils, therefore care should be taken in areas where oil may be deposited on the pipe, such as next to engineering machinery or air compressors. Where chemicals are in use, susceptable piping materials should be routed away from possible contamination.

Heavy equipment

Above ground heavy equipment such as valves or strainers should be supprted independently so as not to place a stress load on to the plastic pipe. An ideal solution for flanged equipment is to use metal valve support plates in place of standard backing rings on the plastic flanges. These can be securely fixed to adjacent masonary or steelwork.

Pipe support centres

PVC-U - ASTM Dimensions

Pipe support intervals in metres at:

DN inch	Schedule 40 15°C	25°C	40°C	50°C	60°C	Schedule 80 15°C	25°C	40°C	50°C	60°C
/″	1.2	1.1	1.1	0.6	0.6	1.2	1.2	1.1	0.8	0.6
3/8″	1.2	1.2	1.1	0.8	0.6	1.4	1.4	1.2	0.8	0.8
fi″	1.4	1.4	1.2	0.8	0.8	1.5	1.4	1.4	0.9	0.8
fl″	1.5	1.4	1.2	0.8	0.8	1.7	1.5	1.4	0.9	0.8
1″	1.7	1.5	1.4	0.9	0.8	1.8	1.7	1.5	1.1	0.9
1/″	1.7	1.7	1.5	0.9	0.9	1.8	1.8	1.7	1.1	0.9
1fi″	1.8	1.7	1.5	1.1	0.9	2.0	1.8	1.7	1.1	1.1
2″	1.8	1.7	1.5	1.1	0.9	2.1	2.0	1.8	1.2	1.1
2fi″	2.1	2.0	1.8	1.2	1.1	2.3	2.3	2.0	1.4	1.2
3″	2.1	2.1	1.8	1.2	1.1	2.4	2.3	2.1	1.4	1.2
4″	2.3	2.1	2.0	1.4	1.1	2.7	2.4	2.1	1.4	1.2
5″	2.4	2.3	2.1	1.4	1.1	2.9	2.7	2.3	1.7	1.4
6″	2.6	2.4	2.3	1.5	1.4	3.0	2.9	2.7	1.8	1.4
8″	2.7	2.6	2.4	1.5	1.4	3.4	3.2	2.9	2.0	1.7
10″	3.0	2.7	2.6	1.7	1.5	3.7	3.4	3.0	2.1	1.8
12″	3.5	3.4	3.0	2.1	1.8	4.0	3.7	3.2	2.3	2.0
14″	3.7	3.4	3.0	2.1	1.8	4.1	4.0	3.4	2.4	2.1
16″	3.8	3.5	3.2	2.3	2.0	4.3	4.1	3.5	2.6	2.3
18″	4.0	3.7	3.4	2.4	2.1	4.4	4.3	3.7	3.4	2.7
20″	4.3	3.8	3.5	3.0	2.6	4.7	4.4	3.8	3.5	2.9
24″	4.6	4.0	3.8	3.4	2.9	5.2	4.6	4.3	3.8	3.2

PVC-U - BS Dimensions

Pipe support intervals in metres at:

DN inch	20°C	30°C	40°C	50°C	60°C
3/8″	0.7	0.7	0.6	0.5	0.4
fi″	0.8	0.8	0.7	0.6	0.5
fl″	0.9	0.9	0.8	0.6	0.5
1″	1.0	1.0	0.9	0.9	0.6
1/″	1.1	1.1	0.9	0.7	0.6
1fi″	1.2	1.1	1.0	0.8	0.7
2″	1.4	1.3	1.1	0.9	0.7
3″	1.6	1.5	1.4	1.1	0.9
4″	1.9	1.7	1.6	1.3	1.0
5″	2.1	1.9	1.7	1.4	1.1
6″	2.3	2.1	1.9	1.6	1.2
8″	2.5	2.3	2.1	1.8	1.4
10″	2.8	2.6	2.3	2.0	1.5
12″	3.1	2.8	2.5	2.1	1.7
14″	3.2	3.0	2.7	2.2	1.8
16″	3.4	3.2	2.8	2.4	1.9
18″	3.6	3.4	3.0	2.6	2.0
20″	3.8	3.6	3.2	2.7	2.1
24″	4.2	3.9	3.5	2.9	2.3

These PVC-U pipe support intervals are for BS 3505 Class C pipe. For other pipe classes multiply the support intervals by the following factors:

Class B	0.90
Class D	1.16
Class E	1.21

PVC-U - Metric Dimensions

Pipe support intervals in metres at:

DN mm	OD mm	20°C	30°C	40°C	50°C	60°C
10	16	0.7	0.7	0.6	0.5	0.4
15	20	0.8	0.8	0.7	0.6	0.5
20	25	0.9	0.9	0.8	0.6	0.5
25	32	1.0	1.0	0.9	0.9	0.6
32	40	1.1	1.1	0.9	0.7	0.6
40	50	1.2	1.1	1.0	0.8	0.7
50	63	1.4	1.3	1.1	0.9	0.7
65	75	1.4	1.3	1.1	0.9	0.7
80	90	1.6	1.5	1.4	1.1	0.9
100	110	1.9	1.7	1.6	1.3	1.0
125	140	2.1	1.9	1.7	1.4	1.1
150	160	2.3	2.1	1.9	1.6	1.2
200	225	2.5	2.3	2.1	1.8	1.4
250	280	2.8	2.6	2.3	2.0	1.5
300	315	3.1	2.8	2.5	2.1	1.7

These PVC-U pipe support intervals are for PN10 pipe. For other pipes multiply the support intervals by the following factors:

PN6	0.90
PN12.5	1.16
PN16	1.21

Pipe support centres

PVC-C - ASTM Dimensions Pipe support intervals in metres at:

DN	Schedule 40					Schedule 80				
inch	20°C	40°C	60°C	70°C	80°C	20°C	40°C	60°C	70°C	80°C
fi″	1.5	1.4	1.2	0.8	0.8	1.7	1.4	1.4	0.9	0.8
fl″	1.5	1.4	1.2	0.8	0.8	1.7	1.5	1.4	0.9	0.8
1″	1.7	1.5	1.4	0.9	0.8	1.8	1.7	1.5	1.1	0.9
1/″	1.7	1.7	1.5	0.9	0.9	2.0	1.8	1.7	1.1	0.9
1fi″	1.8	1.7	1.5	1.1	0.9	2.1	1.8	1.7	1.1	1.1
2″	1.8	1.7	1.5	1.1	0.9	2.1	2.0	1.8	1.2	1.1
2fi″	2.1	2.0	1.8	1.2	1.1	2.4	2.3	2.0	1.4	1.2
3″	2.1	2.1	1.8	1.2	1.1	2.4	2.3	2.1	1.4	1.2
4″	2.3	2.1	2.0	1.4	1.2	2.6	2.6	2.1	1.4	1.2
6″	2.6	2.3	2.1	1.5	1.4	3.0	2.7	2.4	1.7	1.4
8″	2.9	2.6	2.3	1.7	1.5	3.4	3.0	2.7	1.8	1.7
10″	3.2	2.9	2.4	1.8	1.7	3.5	3.2	2.9	2.0	1.8
12″	3.5	3.0	2.6	2.0	1.8	3.8	3.5	3.2	2.3	2.0
14″	3.7	3.0	2.7	2.4	1.8	4.6	3.8	3.4	2.9	2.4
16″	4.0	3.4	2.9	2.6	2.1	4.9	4.1	3.7	3.0	2.6

ABS

DN	DN	Pipe support intervals in metres at:		
inch	mm	20°C	40°C	60°C
$^3/_8$″	16	0.8	0.5	0.4
fi″	20	0.9	0.6	0.5
fl″	25	1.0	0.7	0.6
1″	32	1.1	0.8	0.7
1/″	40	1.2	0.9	0.7
1fi″	50	1.3	1.0	0.7
2″	63	1.4	1.1	0.8
2fi″	75	1.5	1.2	0.8
3″	90	1.6	1.2	0.9
4″	110	1.8	1.3	1.0
	125	1.9	1.4	1.0
5″	140	2.0	1.5	1.1
6″	160	2.1	1.6	1.2
	200	2.2	1.7	1.3
8″	225	2.3	1.8	1.5
	250	2.5	2.0	1.7
10″	280	2.7	2.2	1.9
12″	315	2.9	2.4	2.1

These ABS pipe support intervals are for Class C and PN10 pipe. For other pipe classes multiply the support intervals by the following factors:

Class D	1.05
Class E	1.10

PE80 - SDR11

DN	OD	Pipe support intervals in metres at:				
mm	mm	20°C	30°C	40°C	50°C	60°C
10	16	0.5	0.5	0.5	0.4	0.4
15	20	0.6	0.6	0.5	0.5	0.4
20	25	0.7	0.6	0.6	0.6	0.5
25	32	0.8	0.8	0.7	0.7	0.6
32	40	0.9	0.9	0.8	0.8	0.7
40	50	1.0	1.0	0.9	0.9	0.8
50	63	1.2	1.2	1.1	1.0	0.9
65	75	1.4	1.3	1.2	1.1	1.0
80	90	1.5	1.5	1.4	1.3	1.2
100	110	1.7	1.6	1.5	1.5	1.3
110	125	1.8	1.7	1.6	1.6	1.4
125	140	1.9	1.9	1.8	1.7	1.5
150	160	2.1	2.0	1.9	1.8	1.6
160	180	2.2	2.1	2.0	1.9	1.8
180	200	2.3	2.2	2.1	2.0	1.9
200	225	2.5	2.4	2.3	2.2	2.1
225	250	2.6	2.5	2.4	2.3	2.1
250	280	2.8	2.7	2.6	2.4	2.2
300	315	2.9	2.8	2.7	2.6	2.4
350	355	3.1	3.0	2.9	2.8	2.6
400	400	3.3	3.2	3.1	2.9	2.7

These PE pipe support intervals are for PE80 SDR11 pipe. For other pipes multiply the support intervals by the following factors:

SDR 33	0.75
SDR 17	0.91
SDR 7.4	1.07

There are no valid creep modulus curves available for PE100 at the moment, therefore it is recommended that the values for PE80 be increased by a factor of 1.10.

Pipe support centres

PP-H - SDR11

DN mm	OD mm	Pipe support intervals in metres at: 20°C	30°C	40°C	50°C	60°C	70°C	80°C
10	16	0.7	0.6	0.6	0.6	0.6	0.5	0.5
15	20	0.7	0.7	0.7	0.6	0.6	0.6	0.6
20	25	0.8	0.8	0.8	0.7	0.7	0.7	0.7
25	32	1.0	0.9	0.9	0.9	0.9	0.8	0.8
32	40	1.1	1.1	1.1	1.0	1.0	0.9	0.9
40	50	1.3	1.2	1.2	1.2	1.1	1.1	1.0
50	63	1.5	1.4	1.4	1.4	1.3	1.3	1.2
65	75	1.6	1.5	1.5	1.4	1.4	1.3	1.3
80	90	1.7	1.6	1.6	1.5	1.5	1.4	1.4
100	110	1.9	1.8	1.8	1.7	1.6	1.5	1.4
110	125	2.0	2.0	1.9	1.8	1.7	1.6	1.5
125	140	2.1	2.1	2.0	1.9	1.8	1.7	1.6
150	160	2.3	2.2	2.1	2.0	1.9	1.8	1.7
160	180	2.4	2.3	2.2	2.1	2.0	1.9	1.8
180	200	2.5	2.4	2.3	2.2	2.1	2.0	1.9
200	225	2.7	2.6	2.5	2.4	2.3	2.2	2.0
225	250	2.8	2.7	2.6	2.5	2.4	2.3	2.2
250	280	3.0	2.9	2.8	2.7	2.6	2.5	2.3
300	315	3.2	3.1	3.0	2.9	2.7	2.6	2.5
350	355	3.4	3.3	3.2	3.0	2.9	2.8	2.6
400	400	3.6	3.5	3.4	3.2	3.1	2.9	2.8

These PP pipe support intervals are for PP-H SDR11 pipe. For other pipes multiply the support intervals by the following factors:

SDR 33	0.75
SDR 17	0.91
SDR 7.4	1.07

For PP-R pipes, multiply the support intervals by the following factors:

SDR 33	0.55
SDR 17	0.70
SDR 11	0.75
SDR 7.4	0.80

PVDF - SDR21 (16-50mm), SDR33 (63-400mm)

DN mm	OD mm	Pipe support intervals in metres at: 20°C	30°C	40°C	50°C	60°C	70°C	80°C	100°C	120°C
10	16	0.7	0.7	0.7	0.6	0.6	0.6	0.5	0.5	0.4
15	20	0.9	0.8	0.8	0.8	0.7	0.7	0.6	0.5	0.5
20	25	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.6	0.5
25	32	1.1	1.1	1.0	1.0	0.9	0.9	0.8	0.7	0.6
32	40	1.2	1.2	1.1	1.1	1.0	1.0	0.9	0.8	0.7
40	50	1.4	1.4	1.3	1.2	1.2	1.1	1.0	0.9	0.8
50	63	1.4	1.4	1.3	1.3	1.2	1.2	1.1	1.0	0.8
65	75	1.5	1.5	1.4	1.4	1.3	1.3	1.2	1.1	0.9
80	90	1.6	1.6	1.5	1.5	1.4	1.4	1.3	1.1	1.0
100	110	1.8	1.8	1.7	1.7	1.6	1.5	1.5	1.3	1.1
110	125	1.9	1.9	1.8	1.7	1.7	1.6	1.5	1.4	1.2
125	140	2.0	2.0	1.9	1.8	1.8	1.7	1.6	1.5	1.3
150	160	2.2	2.1	2.1	2.0	1.9	1.8	1.7	1.6	1.4
160	180	2.3	2.2	2.2	2.1	2.0	1.9	1.8	1.6	1.4
180	200	2.4	2.4	2.3	2.2	2.1	2.0	1.9	1.7	1.5
200	225	2.6	2.5	2.4	2.3	2.2	2.1	2.0	1.8	1.6
225	250	2.7	2.6	2.5	2.4	2.3	2.2	2.1	1.9	1.7
250	280	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.0	1.8
300	315	3.0	3.0	2.9	2.8	2.6	2.5	2.4	2.2	1.9
350	355	3.2	3.1	3.0	2.9	2.8	2.7	2.5	2.3	2.0
400	400	3.4	3.3	3.2	3.1	3.0	2.8	2.7	2.4	2.1

These PVDF pipe support intervals are for SDR33 pipes and for SDR21 pipes in diameters from 16 to 50mm. For SDR21 pipes in diameters larger than 50mm, multiply the support intervals by 1.08.

Note that the tables above show support intervals for pipes handling fluids. For pipes handling gases with a density of <0.01g/cm³, it is possible to increase the support intervals shown in the tables by approximately 25% for thinner wall pipes and by approximately 50% for heavier wall pipes.

Environmental conditions

Cold weather

Plastic piping systems generally work well in low temperature conditions. The tensile strength increases as temperature decreases. However, the impact strength of most thermoplastics decreases at low temperatures, and brittleness can develop. This is most evident in systems manufactured from PVC-U or PVC-C, where impact strength is significantly reduced at temperatures below 5°C. Other thermoplastic piping performs particularly well in cold conditions - even at temperatures as low as -40°C.

When PVC-U or PVC-C are installed in a low temperature environment, or if they are to handle fluids at low temperature, they should be installed in a position where the risk of impact is minimised. In addition, every precaution should be taken to minimise hydraulic shock in the system by paying particular attention to fluid velocity, valve opening and closing times, and pump start-ups.

Many standard cold weather piping design and installation practices can be used to protect plastic piping systems from freezing, including pipe insulation, anti-freeze solutions, and trace heating. However all products should be checked for compatability with plastic piping prior to use.

Weatherability

All plastic piping is subject to limitations on use at upper temperatures. This is because the tensile strength of the material decreases as the temperature rises. Care should therefore be taken to ensure that the environmental temperature does not cause the pipe to exceed the safe operating pressure. Refer to the section dealing with pressure and temperature for more information.

Exposure to weather generally has minimal effect on thermoplastic pipes installed outdoors. In extreme conditions, wind carrying solids may result in erosion, and high humidity may contribute to hydrolysis leaching. However these situations are very rare, and when considering the weatherability of any installation, consideration should of course be given to the geographical location - determining if extreme weather may be a posibilty.

In most exposed installations, sunlight (UV radiation) is the factor that will require most consideration. The effects of UV radiation can include surface degradation of the material as well as potentially introducing stresses from unexpected thermal expansion or contraction.

PVC-U, PVC-C and Black Polyethylene are generally resistant to the effects of UV radiation, although some surface discolouration may occur. Polypropylene and ABS are more affected by UV radiation to varying degrees dependent upon the conditions. Natural Polypropylene is not resistant to UV radiation and must be protected if used outdoors. PVDF has excellent resistance to UV radiation, but it should be noted that UV radiation can penetrate the translucent wall and may affect the fluid being handled.

Plastic piping exposed to UV radiation may be protected by painting with a light coloured acrylic or latex paint, or with a coating specifically manufactured for this purpose, such as AGRUCOAT. Oil based paints must not be used.

System design

Guidelines for buried plastic piping

Plastic piping is suitable for installation below ground. Indeed its corrosion resistance makes it ideal for this application. Installed correctly it will give a long, trouble-free service life.

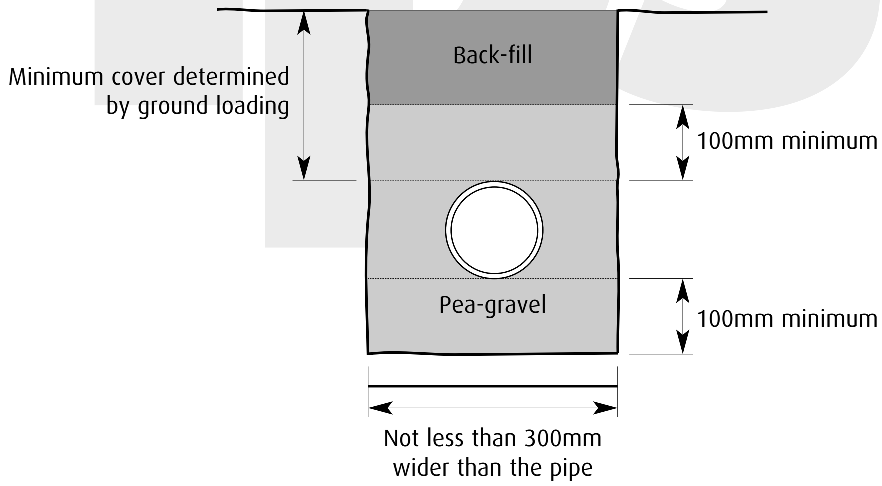
Trenches

Trenches should be dug to a width of not less than 300mm wider than the diameter of the pipe. A trench width of two to three times the pipe diameter is a good general guide. The trench bottom should be free of any sharp objects that may damage the pipe or cause a point loading. All rocks and large stones should be removed to permit a minimum bedding thickness of 100mm below the pipe.

The depth of the trench is determined by the ground loadings after back-filling. As a guide, the following is recommended:

- A minimum cover of 450mm or one pipe diameter (whichever is greater) where there is no overland traffic.
- A minimum cover of 1000mm where there is vehicle traffic expected.
- A minimum cover of 1500mm where there is heavy truck or rail traffic expected.

The trench bottom should have a minimum 100mm pea-gravel bedding. Pipe diameters up to 200mm can usually be installed in the trench, or it can snake or bend from the surface to the bed of the trench to allow for jointing. With larger diameter pipes, it may be preferable to join lengths of pipe on the surface before placing the joined length into the trench.The use of pipe rollers is strongly recommended for making up long pipe lengths. When lifting joined lengths, rope or band slings must be used to prevent damage to the pipe. Joined lengths of pipe must never be rolled into a trench, as twisting stresses can occur.



Pipe Bending Radii

Changes of direction may be made by laying thermoplastic pipes on a gradual curve.The flexibility of thermoplastic pipes means that minor deviations can be taken up by the pipe without the use of fittings.

The minimum radius of any such curvature on PVC-U, PVC-C, ABS, PVDF and Polypropylene pipes is 150 times the nominal diameter of the pipe.

Polyethylene pipes may be installed with smaller bending radii (depending upon the installation temperature conditions):

PE installation temperature +20°C: minimum bending radius 20 x outside diameter
PE installation temperature +10°C: minimum bending radius 35 x outside diameter
PE installation temperature +5°C: minimum bending radius 50 x outside diameter

System design

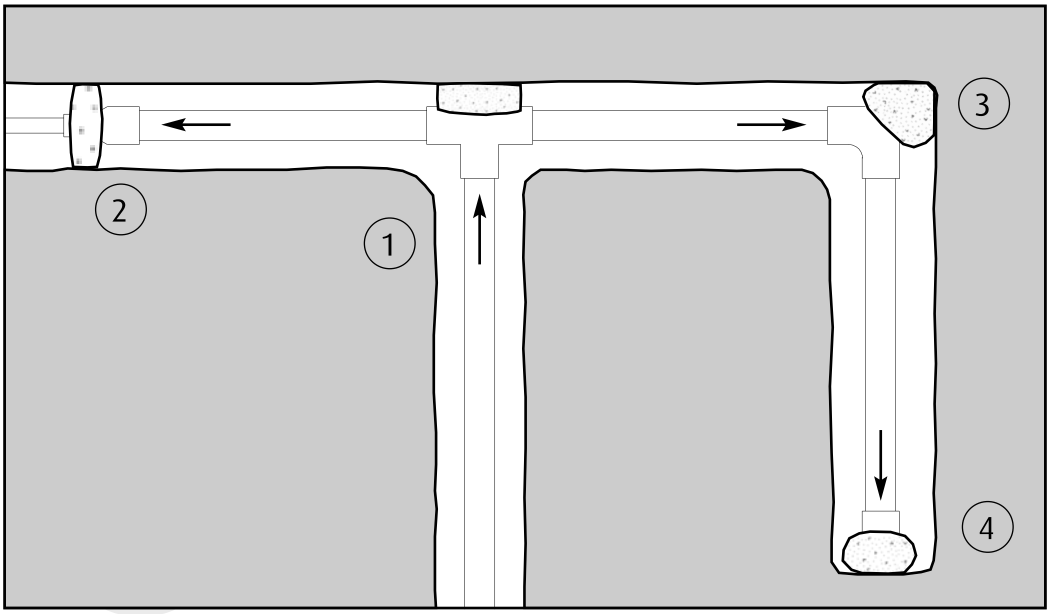
Guidelines for buried plastic piping

Thrust blocking

Thrust blocks are essential for buried plastic pipe systems that use push-fit gasket joints, and may also be useful in other systems as a means of controlling hydraulic shock.

Thrust forces are usually encountered:

1. At the back of a tee
2. At a reduction in pipe diameter
3. At a change of direction
4. At a blank end



The size and type of thrust block depends upon the pipe size, the type of fitting, soil properties and the water-hammer possibilities. The most common method is to pour concrete (to the size required) between the pipe fitting and the bearing wall of the trench. A thin membrane such as polyethylene film should be laid between the concrete and the plastic pipe. As a guide to assist with thrust block design, the following table shows the typical thrust forces in kN for a range of pipe sizes and fitting configurations:

DN	OD	Thrust forces in kN:				
mm	mm	Tee, Cap or Blank	90° Bend	45° Bend	22fi° Bend	11⁄° Bend
80	90	0.64	0.91	0.49	0.25	0.13
100	110	0.95	1.36	0.73	0.37	0.19
150	160	2.01	2.87	1.55	0.79	0.40
180	200	3.14	4.49	2.43	1.24	0.62
225	250	4.91	7.01	3.80	1.93	0.97
300	315	7.79	11.13	6.03	3.07	1.54
400	400	12.57	17.95	9.72	4.95	2.49