Expansion & Contraction

	Page
Expansion & Contraction Introduction	**6.02**
Change in length	6.03
Allowing for expansion or contraction	6.04 - 6.07
Bracket spacing	6.08 - 6.12

6

Expansion and Contraction

All materials expand or contract with the increase or decrease in temperature. The amount of this expansion or contraction is dependent on the coefficient of linear expansion α. This coefficient is very rarely linear for a material, however for most calculations a good average is used.

The average linear expansion coefficient of polybutylene (PB):

ΔL = change in length
L = pipe length

α = 0.013 mm/m°C

Therefore

$\Delta L = \alpha \times L \times \Delta t$

Important
Please note that Δt is the difference between the installation temperature and the working temperature.

Where ΔL = change in length in mm
α = coefficient of expansion
L = original length in mm
Δt = temperature difference in °C

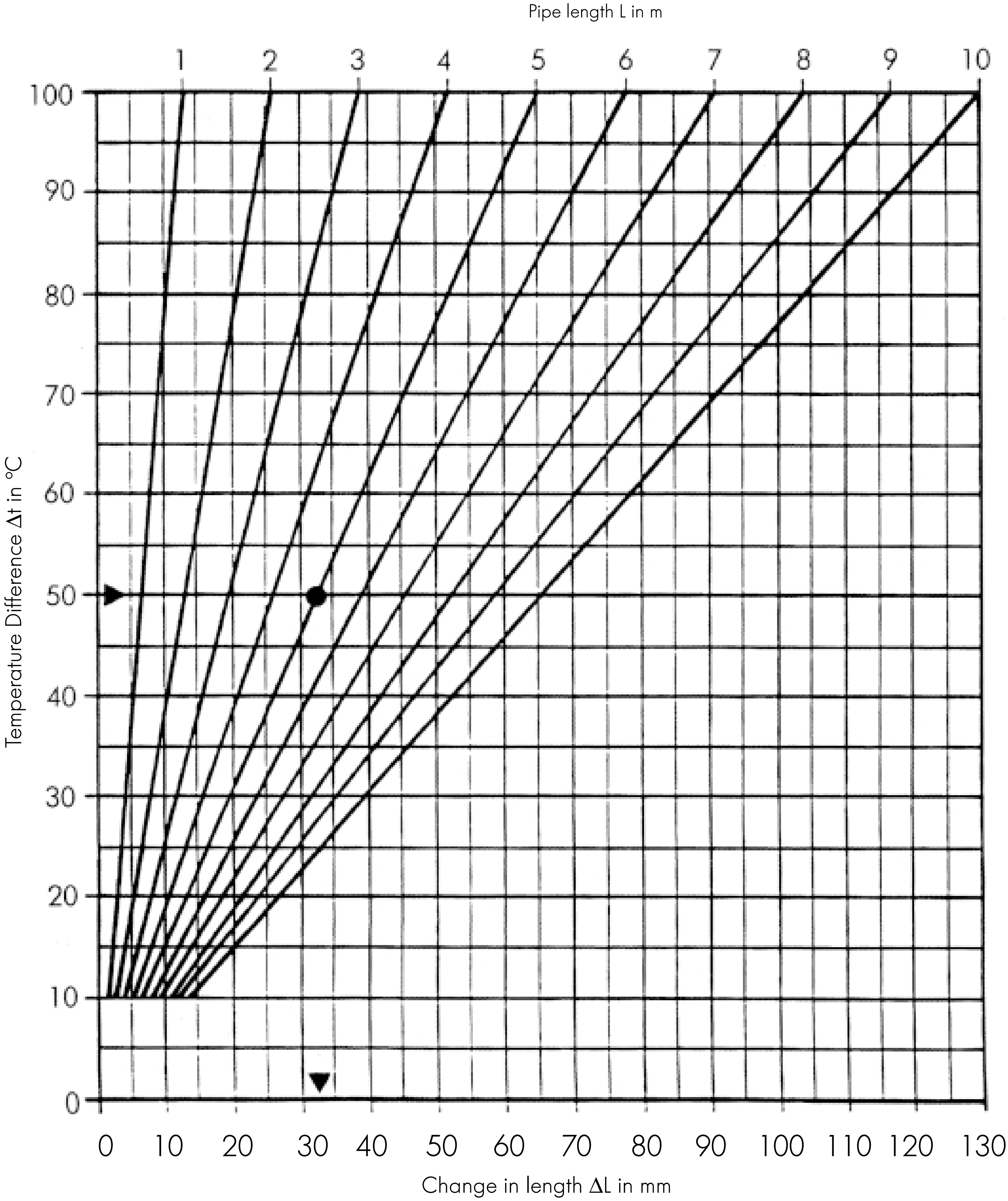
Example
How much will a 10m length of PB (INSTAFLEX) expand if the working temperature is 60°C and the installation temperature is 15°C?
Δt = working temperature - installation temperature
Δt = 60°C –15°C
Δt = 45°C
Therefore
ΔL = 0.13 x 10 x 45
ΔL = 58.5mm

Change in length Δ L in mm for PB pipes

Pipe l. in m	Temperature difference Δt in °C 10	20	30	40	50	60	70	80
0.1	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.0
0.2	0.3	0.5	0.8	1.0	2.0	2.3	2.7	3.1
0.3	0.4	0.8	1.2	1.6	2.0	2.3	2.7	3.1
0.4	0.5	1.0	1.6	2.1	2.6	3.1	3.6	4.2
0.5	0.6	1.3	2.0	2.6	3.3	3.9	4.6	5.2
0.6	0.8	1.6	2.3	3.1	3.9	4.7	5.5	6.2
0.7	0.9	1.8	2.7	3.6	4.6	5.5	6.4	7.3
0.8	1.0	2.1	3.1	4.2	5.2	6.2	7.3	8.3
0.9	1.2	2.3	3.5	4.7	5.9	7.0	8.2	9.4
1.0	1.3	2.6	3.9	5.2	6.5	7.8	9.1	10.4
2.0	2.6	5.2	7.8	10.4	13.0	15.6	18.2	20.8
3.0	3.9	7.8	11.7	15.6	19.5	23.4	27.3	31.2
4.0	5.2	10.4	15.6	20.8	26.0	31.2	36.4	41.6
▸ 5.0	6.5	13.0	19.5	26.0	32.5	39.0	45.5	52.0
6.0	7.8	15.6	23.4	31.2	39.0	46.8	54.6	62.4
7.0	9.1	18.2	27.3	36.4	45.5	54.6	63.7	72.8
8.0	10.4	20.8	31.2	41.6	52.0	62.4	72.8	83.2
9.0	11.7	23.4	35.1	46.8	58.5	70.2	81.9	93.6
10.0	13.0	26.0	39.0	52.0	65.0	78.0	91.0	104.0
11.0	14.3	28.6	42.9	57.2	71.5	85.8	100.1	114.4
12.0	15.6	31.2	46.8	62.4	78.0	93.6	109.2	124.8

Example from table
A 5m long pipe working at a temperature of 50°C will expand or contract by 32.5mm.

Change in length Δ L in mm for PB pipes



Allowing for Expansion or Contraction

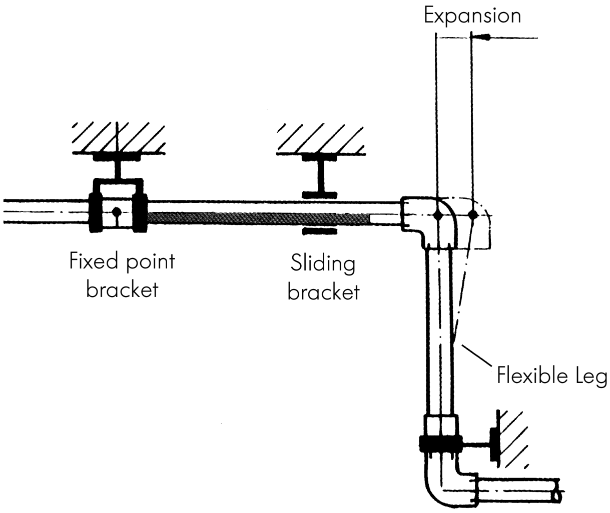
1. General

Being a member of the thermoplastic family, INSTAFLEX PB is subject to greater thermal movement than metals. As all materials expand or contract and since the modulus of elasticity (E) of INSTAFLEX is very low, at 350N/mm^2, overcoming the effects of expansion or contraction is generally easier than with metals. There are **three principal methods** to overcome the effects of thermal movement.

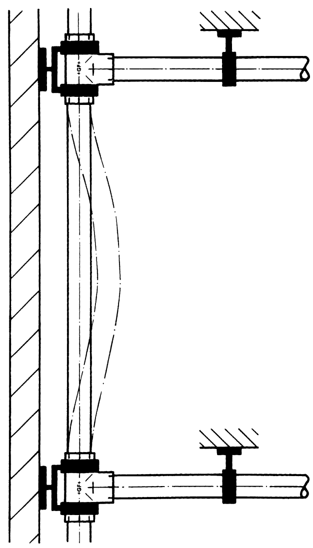
Method 1

By optimising the flexibility of PB by using the changes of direction found in most installations or to install expansion loops. This method is most commonly used in places where the pipework is not visible, i.e. in ceiling voids or riser ducts.

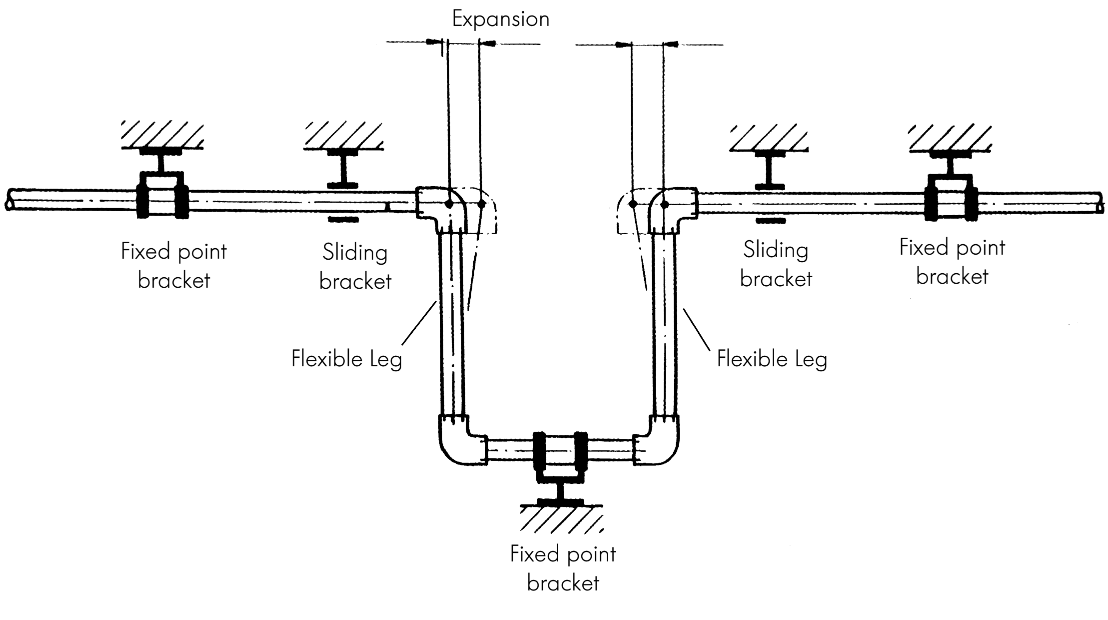
Flexible expansion leg



Pipe lateral yielding in riser



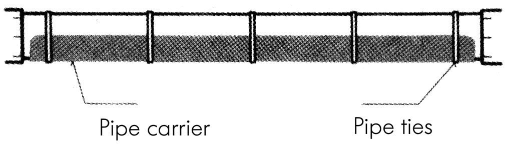
Expansion Loop



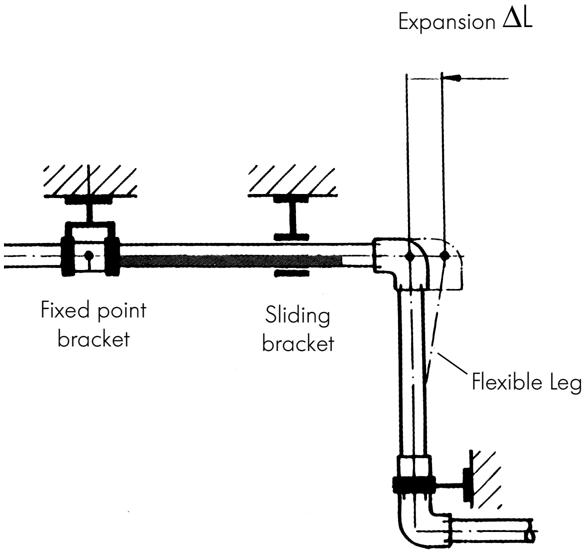
Method 2

Similar to Method 1 but using pipe carrier to continually support the pipe. The advantage of this approach is that pipe is continually supported and the bracket centers can be much further apart.
Ideal for use in areas where the pipe is visible.

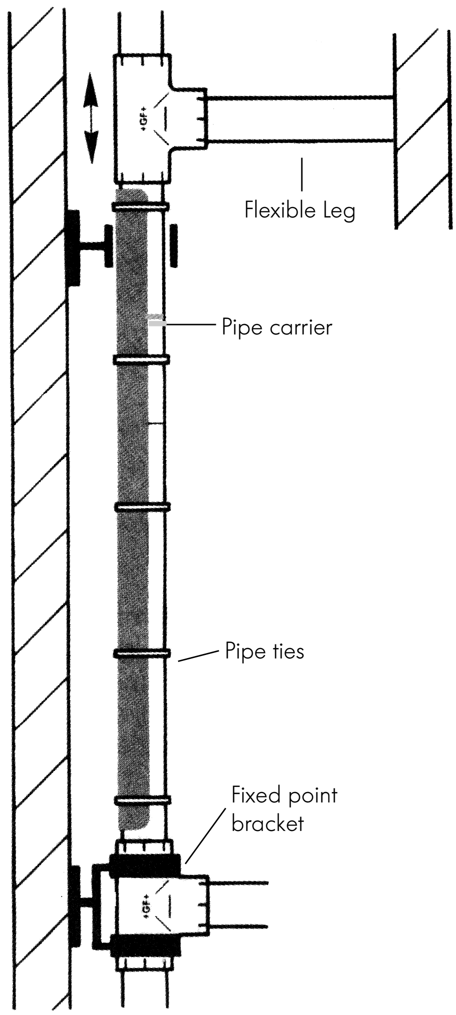
Typical Pipe Carrier



Flexible Expansion Leg with carrier



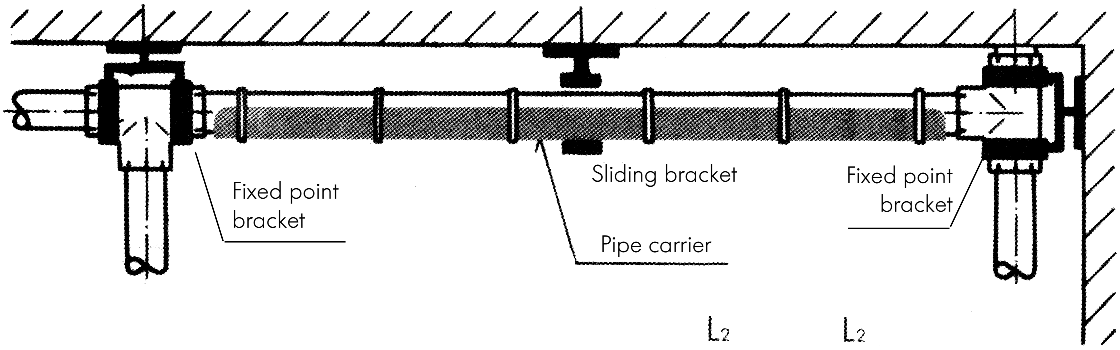
Pipe in Riser Carrier

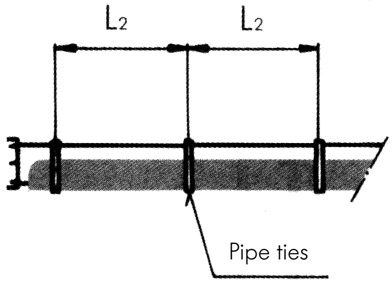


6

Method 3

This method utilises the unique feature of INSTAFLEX, namely its ability to absorb any thermal movement within itself without detriment to the material or system. This is achieved by rigidly fixing the pipework to prevent any thermal movement.
This system is commonly used where there are long pipe runs with laterals.

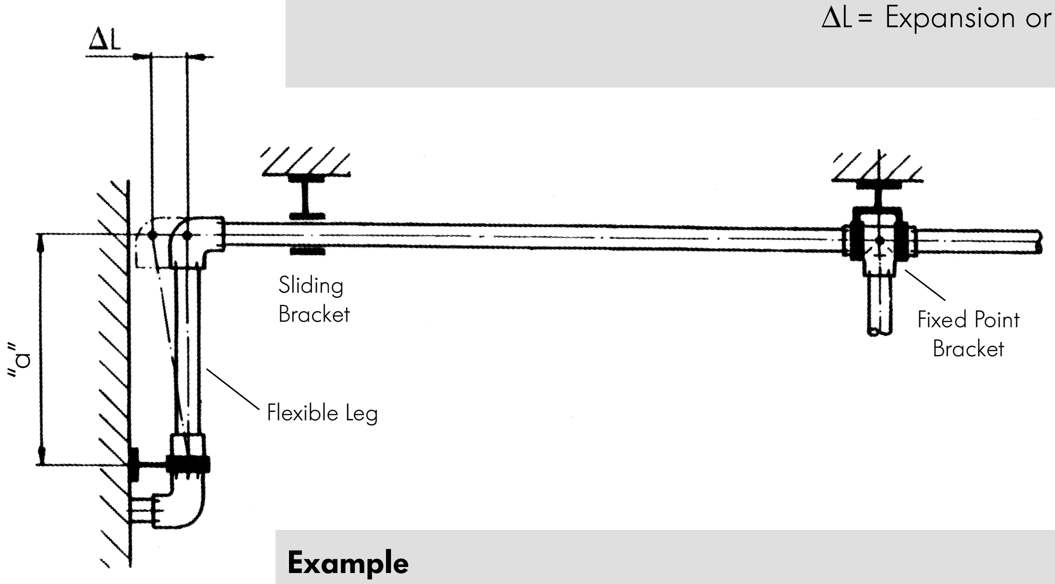




Calculating the Flexible Leg for Methods 1 and 2.

$$\mathbf{a = k \times \sqrt{\Delta L \times od}}$$

where a = flexible leg in cm
k = constant PB = 10
ΔL = Expansion or Contraction in cm



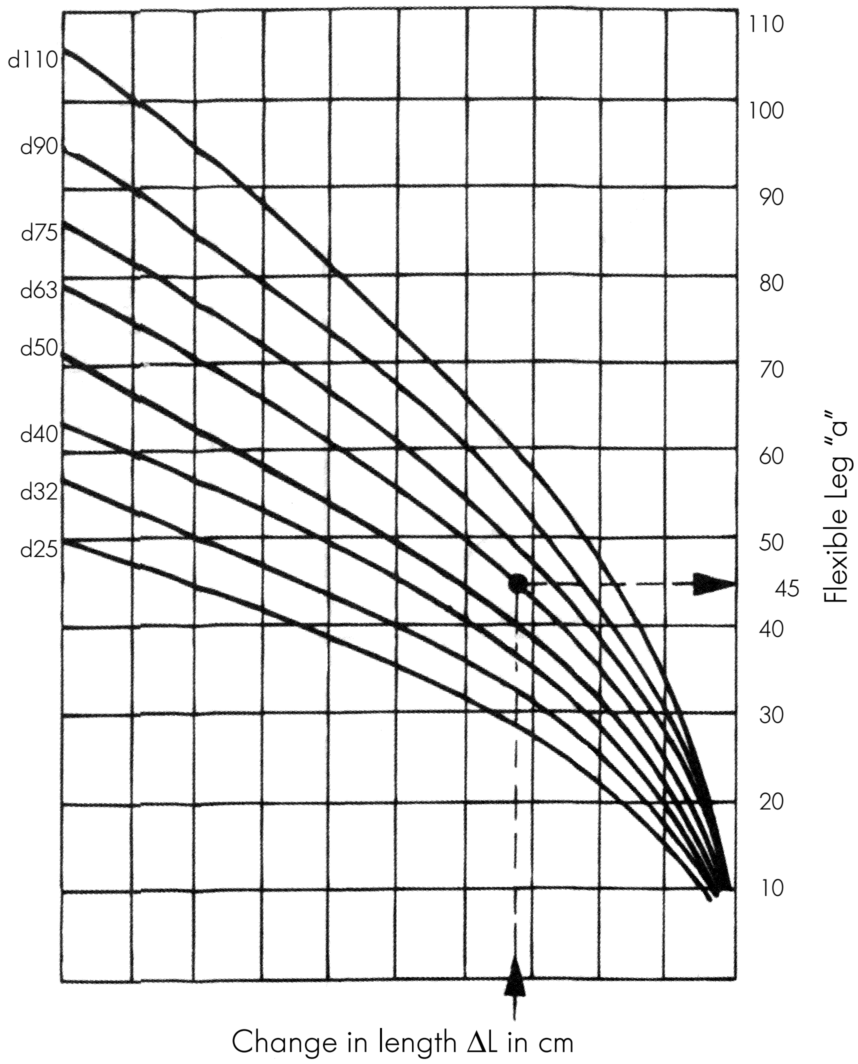
Example
How long should leg "a" be if the expansion ΔL is 3.25cm on a 6.3cm od pipe?

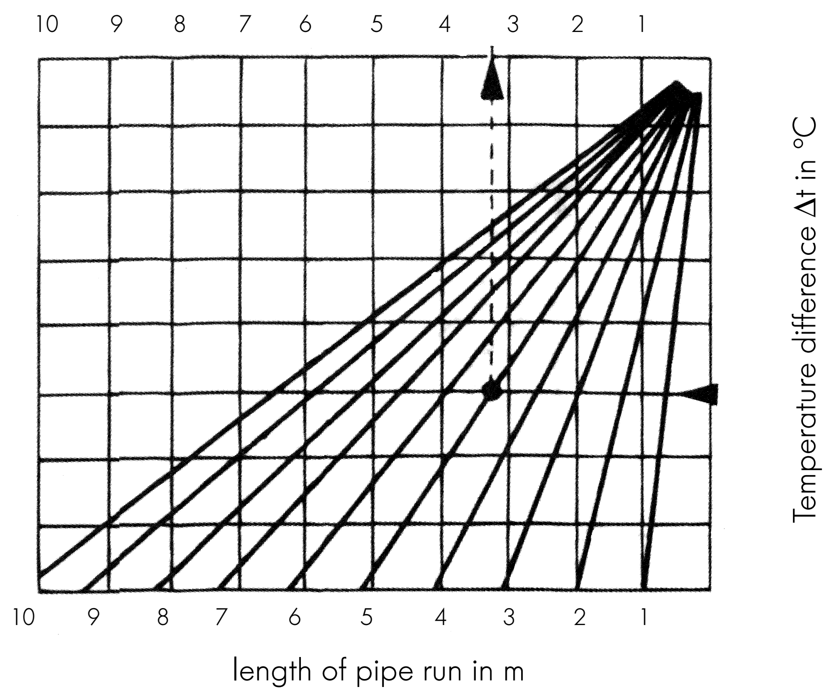
$a = 10 \times \sqrt{3.25 \times 6.3} \simeq \underline{45\text{cm}}$

Graphical method for Determining the Flexible Leg "a"
For methods 1 and 2

General Guidelines

1. Control the direction and amount of thermal movement by careful positioning of fixed points.
2. Take care to ensure the pipe can move freely within the loose brackets.
3. Never create a fixed point by tightening the bracket to squeeze the pipe.
4. Ensure that the positioning of loose bracket does not inadvertently create a fixed point.





Method 1 • Bracket Spacing

Pipe size d	Pipe bracket intervals in cm					
	20°C	30°C	40°C	50°C	60°C	80°C
16	70	70	65	65	60	60
20	75	80	75	75	70	70
25	80	80	80	75	75	70
32	90	90	90	90	85	80
40	105	100	100	95	95	90
50	115	115	110	110	105	100
63	130	130	125	120	120	110
75	140	140	135	130	130	120
90	155	150	150	145	140	130
110	190	190	180	180	170	160

The pipe bracket spacing may be increased by 30% in the case of vertical pipes. i.e. multiply the values given by 1.3.

The bracket spacings above are based on a maximum deflection of 0.25cm between the brackets.

Method 2 • Loose Bracket Spacing with support tray

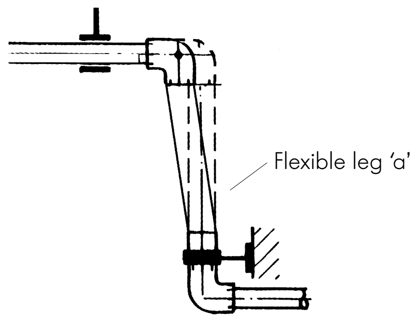
Pipe size d	All Temperatures	Tie Spacing
16 to 75mm	1.5 to 2m maximum	approx. every 30cm
90 & 110 No support tray	1.5 to 2m maximum	approx. every 30cm

Pre-stressing

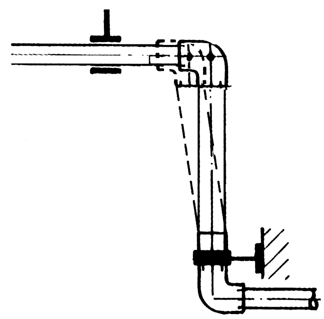
An alternative solution for Methods 1 and 2 is to cut the pipe short by the amount that it is calculated that it will expand or contract, such that when it is at its normal operating temperature the expansion leg or loop is straight.

Note
There must be a Flexible Leg "a"

Position at ambient temperature



Position at operating temperature

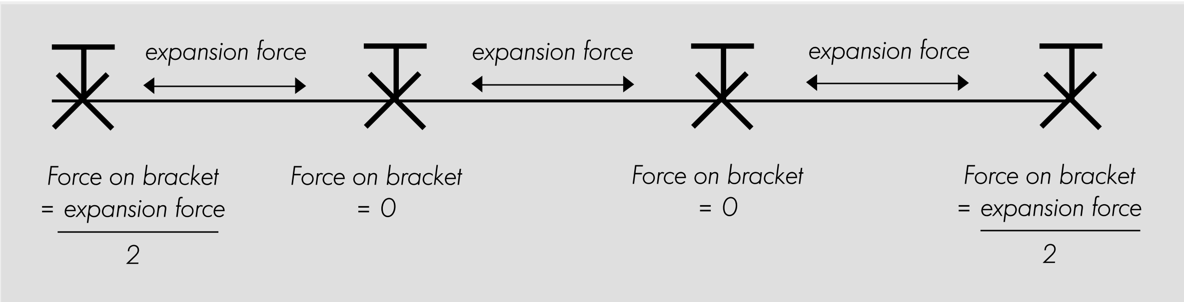


Fixed point assembly Method 3 • Bracket Spacing

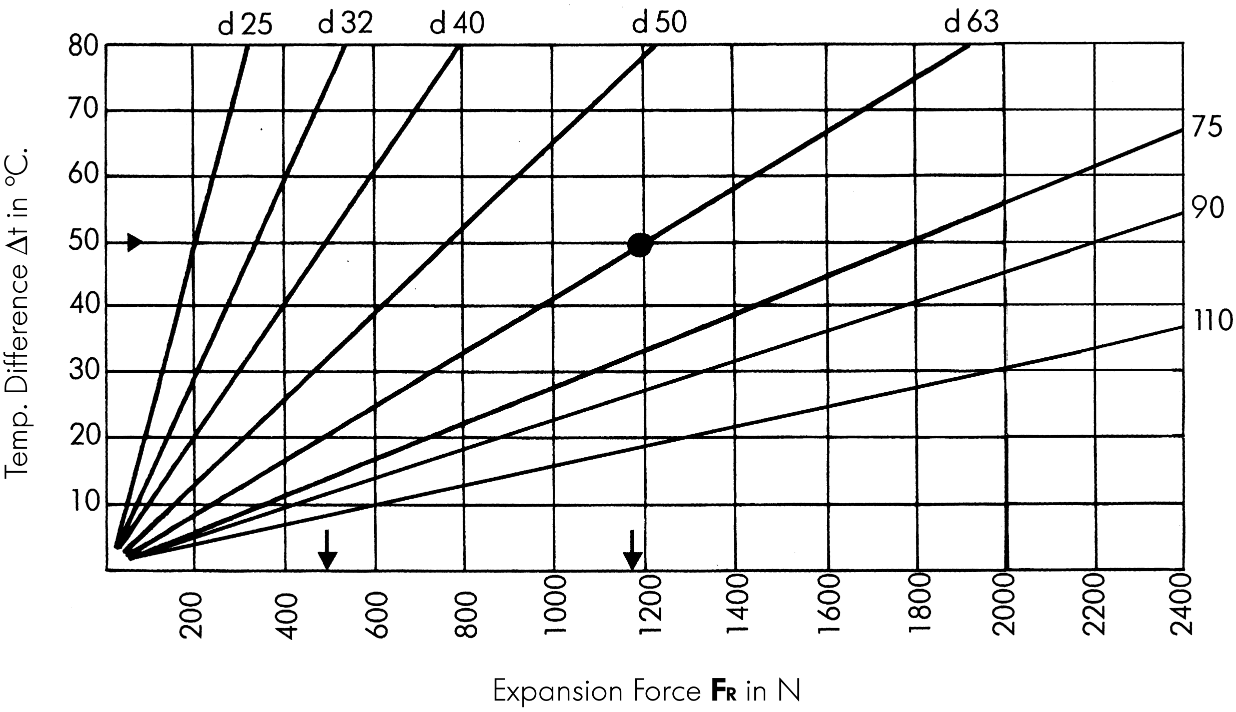
Bracket distances for hot water pipes

Pipe dim d mm	Fixed point distances L	Loose bracket distances L^1	Pipe binder distances L^2
16 20 25 32 40 50 63 75	maximum 6m between fixed points	1.5 to 2m max.	approx every 30cm

For fixed installations the expansion force of the pipe is transferred to the last fixed point brackets.



Expansion Forces generated by PB pipes for Temperature Differences



To calculate the expansion force, the following formula may be used;

$$F_R = \frac{A \times E \times \alpha \times \Delta t°C.}{2}$$

where $$A = \frac{(D^2 - d^2)\,\pi}{4}$$

A = pipe cross section area mm^2

E = modulus of elasticity $350N/mm^2$

α = coefficient of linear expansion
= 0.013mm/m°C

Δt = temperature difference °C

$F_R = \frac{\text{expansion force}}{2}$

Example

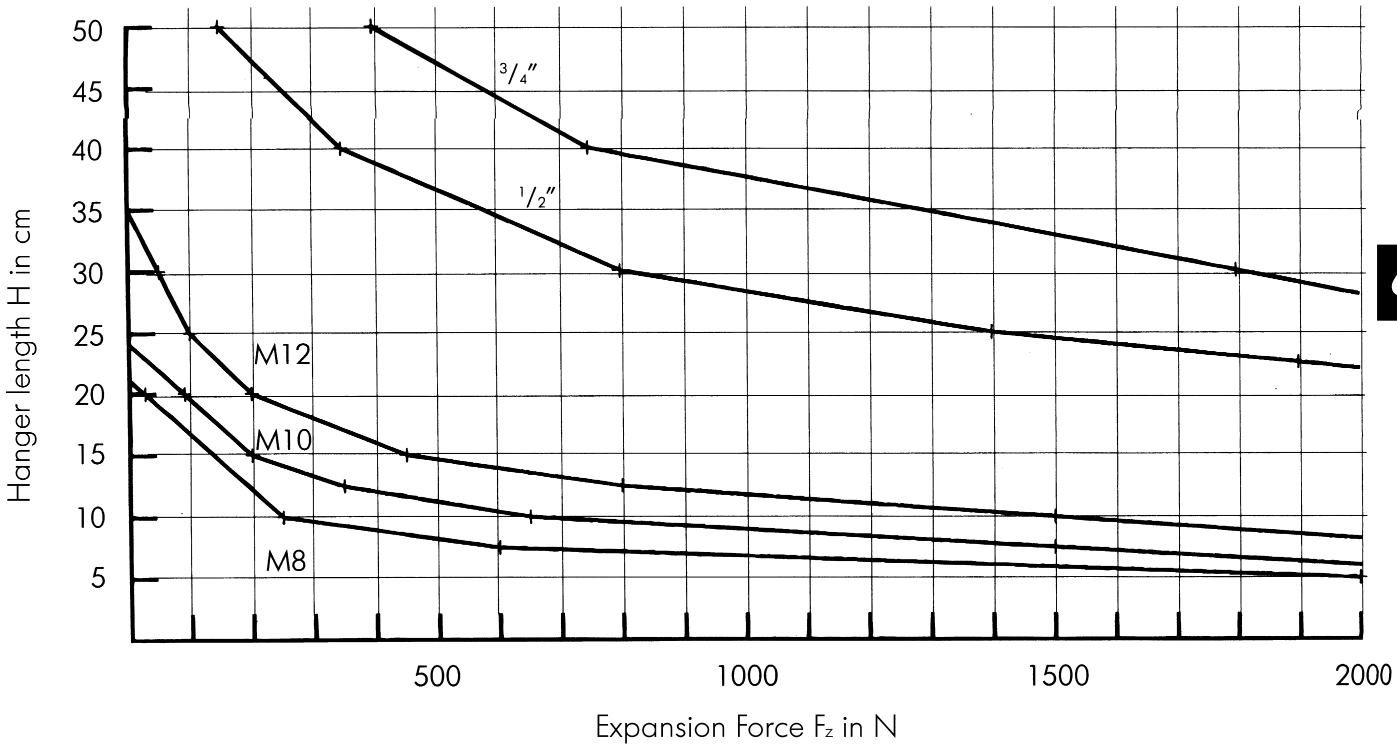
What is the force acting on an end bracket for a 63 mm od pipe with a temperature difference of 50°C?

$$F_R = \frac{(63^2 - 51.4^2)\,\pi \times 350 \times 0.013mm/°C \times 50}{4 \times 2}$$

$\underline{F_R = 1185\ N}$

Forces due to expansion of various sizes of PB pipe which would be transferred to a fixed point pipe support clamp, can be read from the graph on page 11. Depending on how far the centerline of the pipe needs to be from the supporting structure will effect the required diameter of the fastening rod used to hold the fixed point in place. This can be determined using the graph below and the expansion forces on page 11.

Choosing the Diameter of the Fastening Rods for the Pipe Clamp and Bass Plate



Calculating the Fixed Point Support Clamp

D *Diameter of the fastener rods*
H *Distance to ceiling or wall from the pipe*
L *Distance between screws*
X *Number of screws with tensile strength*
F_R *Fixed point forces (N)*
F_Z *Screw or dowel retention force (N)*

2-hole base plate
x = 1
4-hole base plate
x = 2

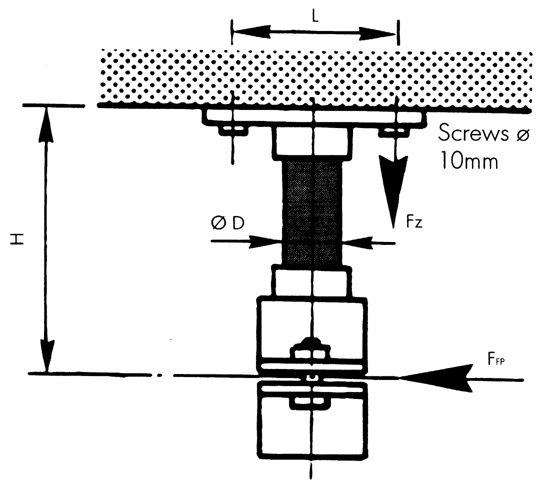
$$F_z = \frac{F_R \times H}{L \times X} \quad [N]$$

Example:

$$F_z = \frac{1200N \times 20cm}{12cm \times 2} \quad \underline{\mathbf{= 1000N}}$$

Retention force per screw:

<u>Fz = 1000N</u>



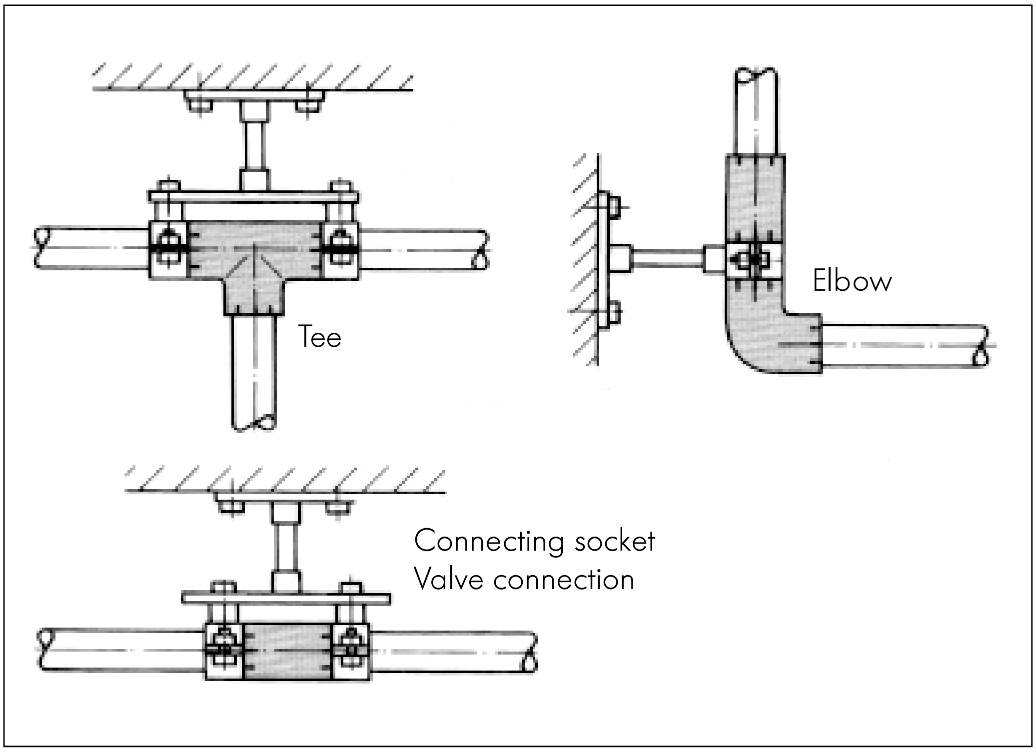
Fixed Point and Sliding Brackets

Arrangement of fixed point support brackets

Fixed points direct thermal expansion of the pipe in the desired direction. Fixed points should ideally be installed at a fitting and should support it on both sides or be installed in between the two fittings.

Attention!

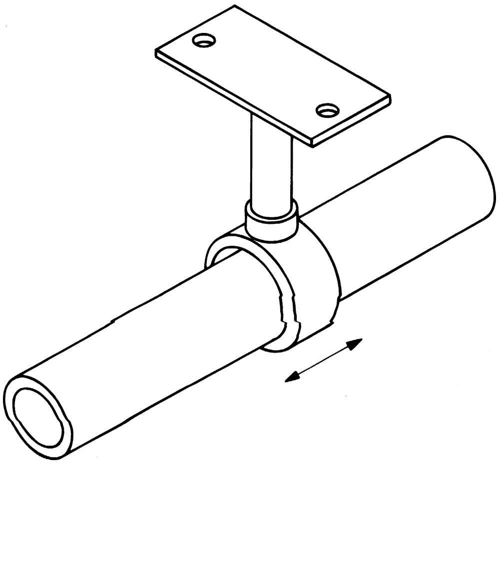
Pipe brackets for fixed point and sliding support should be lined with suitable rubber inserts or of such a design to prevent any damage to the pipe.



Typical fixed point assembly

Sliding support brackets

Sliding brackets allow an axial movement of the pipe. The bracket must be in line with the pipe. Sliding brackets should be lined with rubber inserts suitable for plastic pipe, or of such a design to prevent any damage to the pipe.



All commercially available pipe clamps and fastening materials, which are suitable for plastic pipe installations can be used as fixed points or sliding pipe supports for INSTAFLEX.